F. B. Howell
Wabash College.

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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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VOLUME 56

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P. D. EDWARDS, EDITOR

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Spring Meeting
TURKEY RUN STATE PARK
May 10 and 11, 1946

Sixty-Second Annual Meeting
INDIANA STATE TEACHERS COLLEGE
October 17, 18, and 19, 1946

Copies of the Proceedings may be purchased through the State Library, Indianapolis, Indiana, at $3.00 per volume. All items sent in exchange for the Proceedings and all communications to officers of the Academy, when their names and addresses are not known, should also be sent to the State Library.

Reprints of certain parts of recent volumes of the Proceedings are available for distribution as follows: copies of the constitution and by-laws (Vol. 44), and complete membership list (Vol. 56), may be secured by members elected subsequent to the publication of those volumes; copies of the codified list of duties of officers (Vol. 48) may be secured by officers, divisional chairmen, and chairmen of committees; and copies of the necrology can be supplied to relatives and friends of the deceased members. Inquiries concerning these reprints should be addressed to the Secretary of the Academy, Dr. Winona H. Welch, DePauw University, Greencastle, Indiana.

Reprints of technical papers in recent volumes can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

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OFFICERS AND COMMITTEES FOR 1946

OFFICERS

President, E. F. DEGERING, Purdue University.
Vice-President, N. E. PEARSON, Butler University.
Secretary, WINONA H. WELCH, DePauw University.
Treasurer, W. P. MORGAN, Indiana Central College.
Editor, R. C. CORLEY, Purdue University.
Press Secretary, C. M. PALMER, Butler University.
Trustees of Academy Foundation: J. S. WRIGHT, Eli Lilly & Company (term expires 1948), chairman; F. B. WADE, Shortridge High School (term expires 1947).
Committee for Bonding of Trustees: R. C. FRIESNER, Butler University, chairman; SCOTT MCCOY, Indianapolis.
Research Grant Committee: T. G. YUNCKER, DePauw University (term expires 1949), chairman; E. G. MAHIN, University of Notre Dame (term expires 1947); H. H. REMMERS, Purdue University (term expires 1950); PAUL WEATHERWAX, Indiana University (term expires 1946); J. S. WRIGHT, Indianapolis (term expires 1948); E. F. DEGERING, Purdue University (ex officio); WINONA H. WELCH, DePauw University (ex officio).

DIVISIONAL CHAIRMEN

Anthropology, W. B. ADAMS, Bloomington.
Bacteriology, F. A. MILLER, Eli Lilly & Co., Indianapolis.
Botany, J. E. POTZGER, Butler University.
Chemistry, E. F. DEGERING, Purdue University.
Geology & Geography, G. DAVID KOCH, Indiana State Teachers College.
History of Science, W. E. EDINGTON, DePauw University.
Mathematics, H. E. WOLFE, Indiana University.
Physics, K. W. MEISSNER, Purdue University.
Psychology, C. C. JOSEY, Butler University.
Zoology, H. H. VOGEL, Jr., Wabash College.

EXECUTIVE COMMITTEE

(Past Presidents, Officers, Divisional Chairmen, and Chairmen of Standing Committees)

W. B. Adams, C. A. Behrens, S. Burrage, O. B. Christy, W. A. Cogshall, R. C. Corley, E. R. Cumings, J. J. Davis, C. C. Deam, E. F. Degering, W. E. Edington, H. E. Enders, R. C. Friesner, W. G. Gingery, C. C. Josey, Theodor Just, J. D. Koch, Eli Lilly, J. F. Mackell, E. B. Mahin, C. A. Malott, M. S. Markle, E. S. Martin, K. W. Meissner, M. G.

Mellon, H. H. Michaud, F. A. Miller, W. P. Morgan, C. M. Palmer, F. Payne, N. E. Pearson, J. E. Potzger, R. R. Ramsey, W. E. Ricker, J. E. Switzer, H. H. Vogel, Jr., F. B. Wade, F. N. Wallace, Paul Weatherwax, Winona H. Welch, H. E. Wolfe, J. S. Wright, T. G. Yuncker.

BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairman of Committee on Relation of Academy to State, Program Committee, Library Committee, and Fifty-Year Index Committee)

E. F. Degering, *Chairman;* R. C. Corley, R. C. Friesner, W. G. Gingery, J. F. Mackell, W. P. Morgan, F. N. Wallace, Winona H. Welch.

STANDING COMMITTEES

(Appointed by the President, Chairman of each committee named first)

Auditing: E. S. Martin, Arsenal Technical H. S., Indianapolis; K. S. Means.

Biological Survey: W. E. Ricker, Indiana University; W. P. Allyn, H. O. Deay, R. M. Kriebel (deceased 3-15-1946), H. H. Michaud, B. E. Montgomery, C. M. Palmer, Dorothy Parker, Winona H. Welch.

Fifty-Year Index: R. C. Friesner, Butler University; Nellie M. Coats, W. P. Morgan, F. N. Wallace, Paul Weatherwax.

Invitations: C. M. Palmer, Butler University; A. R. Bechtel, R. M. Cable, Edward Kintner, Fred Loew.

Junior Academy: H. E. Enders and H. H. Michaud, Purdue University; W. P. Allyn, O. B. Christy, F. R. Elliott, M. S. Markle, C. L. Porter, F. B. Wade, M. M. Williams (deceased 4-14-1946), T. G. Yuncker.

Library: W. G. Gingery, Washington H. S., Indianapolis; Nellie M. Coats, R. C. Friesner.

Membership: J. E. Switzer, Indiana University; J. J. Davis, G. F. Hennion, W. E. Martin, J. E. Potzger.

Nominations: T. G. Yuncker, DePauw University; M. S. Markle, P. A. Tetrault.

Program: J. F. Mackell, Indiana State Teachers College; B. A. Howlett, G. D. Koch, R. McDougal, Bessie Noyes, Sister Ignatia.

Publication of Proceedings: R. C. Corley, Purdue University; P. D. Edwards, Paul Weatherwax.

Relation of Academy to State: F. N. Wallace, State Dept. of Conservation; E. Y. Guernsey, Eli Lilly, H. J. Reed, J. S. Wright.

Representative on Council of A.A.A.S.: H. E. Enders and E. F. Degering, Purdue University.

Resolutions: O. B. Christy, Ball State Teachers College; Theodor Just, Naomi Mullendore.

MINUTES OF THE SPRING MEETING

TURKEY RUN STATE PARK

MAY 10, 11, 1946

President Degering called the Executive Committee meeting to order at 4:30 p.m., May 10.

Dr. H. H. Michaud was elected to the chairmanship of the Junior Academy of Science committee to replace Dr. H. E. Enders on June 30, the date of his retirement from Purdue University. Dr. Ender's resignation from this committee was accepted with regret and deep appreciation of his many years of service and interest in the advancement of the Indiana Junior Academy of Science.

Miss Coats, Academy Librarian, requested that members return any duplicate Proceedings to the Academy Library to supply requests from numerous institutions. Miss Coats also wishes for the library the publications of Academy members other than those in the Proceedings.

Pres. Degering stated that the Indiana Academy approved the Magnuson Bill, based upon the returns from the letters circulated concerning this bill. Letters concerning the approval were sent to the Senate Committee on Commerce and the Senate Committee on Military Affairs.

Dr. Yuncker, Chairman of Research Grant Committee, announced that the committee had granted $100.00 to Dr. J. E. Potzger for use in the continuation of his pollen studies.

Meeting adjourned at 5:30.

These minutes were read and approved at the business session preceding the evening program.

Following the dinner a very interesting lecture illustrated with kodachrome slides was presented by Frank Wallace, State Department of Conservation.

On Saturday May 11 four field trips were organized. These trips and the leaders follow:

(1) Botanical hike led by R. D. Friesner and C. M. Palmer.

(2) Bird trip led by Sidney R. Esten.

(3) Conservation and Wildlife trip led by H. H. Michaud.

(4) Geology trip led by O. W. Freeman.

PROGRAM OF THE WINTER MEETING

INDIANA STATE TEACHERS COLLEGE

October 17-19, 1946

THURSDAY, OCTOBER 17

7:30 P. M.

Meeting of the Executive Committee.

FRIDAY, OCTOBER 18

9:00 A.M. General Session

Address of Welcome. Dean J. E. Grinnell, Indiana State Teachers College.

Response. President E. F. Degering.

Business Session.

Necrology Report. W. E. Edington, DePauw University.

"The Uniform Turns to Science". Capt. M. J. Lawrence, Assistant Chief Research and Inventions, Washington, D. C.

1:00 P. M. Sectional Meetings

6:00 P. M. Annual Dinner

Business Session.

President's Address. "The Seven Freedoms". E. F. Degering, Purdue University.

SATURDAY, OCTOBER 19

9:00 A. M.

Meeting of Plant Taxonomists.
Junior Academy of Science.

1:00 P. M.

Junior Academy of Science.

MINUTES OF THE EXECUTIVE COMMITTEE

TERRE HAUTE, OCTOBER 17, 1946

The Executive Committee was called to order by President Degering in the Ballroom of the Student Union Building of Indiana State Teachers College, at 7:45 p.m. The reports of officers and committee representatives were presented and accepted as follows:

Academy Trustee. Report of John S. Wright, Frank B. Wade, and W. P. Morgan, Trustees of the Foundation Fund, Indiana Academy of Science for the year 1945-1946.

Balance from the previous year		$332.62
Total receipts		151.00
Check from W. P. Morgan, Treasurer		25.00
Total		$508.62
Expenditures		
Union Trust Co. Fee 5% on $151.00	$7.55	
Purchase $500. Series G Bonds	500.00	507.55
Cash Balance at Union Trust Company		$1.07

Assets in the Fund as of September 30, 1946

(5)	$1,000.00 U. S. Savings Bonds Series "D" Cost	$3,750.00
	$6,900.00 U. S. Treasury Bonds Series "G" Cost	6,900.00
(6)	Shares Standard Oil of Indiana Common Stock Par	150.00
	TOTAL AT PAR OR COST	$10,800.00

Treasurer. W. P. Morgan presented a tentative financial report for the period from January 1, 1946 to October 1, 1946. His final report, approved by the Auditing Committee at the end of the year, follows:

Receipts

Balance on hand January 1, 1946	$2,343.48	
Dues and initiation fees	1,053.00	
Refund for research from A.A.A.S.	100.00	
Returned portion of research grant	46.35	
Designated gift	12.50	
Designated gift	250.00	
Publications sold by Librarian	5.83	
Author's reprints Vol. No. 52	4.16	
Author's reprints Vol. No. 54	290.70	
		$4,106.02

Disbursements

1—Program Committee	$ 207.56
2—Editor Vol. No. 55	200.00
3—Expenses of Secretary	79.56

4—Expenses of Treasurer	73.00	
5—Mailing Proceedings	42.00	
6—Stationery	108.55	
7—Surety Bond	25.00	
8—Research grant to J. A. Potzger	75.00	
9—Publication for library	2.00	
10—*To S. S. Visher for copy American Men of Science	12.50	
11—Returned checks	8.00	
12—Cost of reprints Vol. No. 55	unpaid	
		$ 833.17
**Balance on hand		$3,272.85
		$4,106.02

* Paid from designated gift.

** Balance includes $1,246.25 in gifts designated for the completion of work on the fifty-year index and the preparation for publication of the "Indiana Men of Science".

(Signed) W. P. MORGAN, *Treasurer.*

(Signed) ERSIE S. MARTIN,
KARL S. MEANS, *Auditors.*

Auditing Committee. E. S. Martin reported the accounts of the Academy Trustees and the Treasurer to be in good order.

Bonding Committee. R. C. Friesner reported that the cost of bonding the treasurer and trustees, $25.00, had been paid to the Hartford Accident and Indemnity Company, Indianapolis, Indiana.

Editor and Publication of Proceedings. R. C. Corley reported that 1500 copies of the Proceedings and 5900 reprints had been ordered.

Research Grant. T. G. Yuncker reported two refunds which have been credited to the Research Fund; $75.00 from the estate of Dr. Foley, an unexpended amount of a grant made previous to his death; and $46.35 from Dr. William D. Gray, an unexpended portion of a grant which can not be used because of his out-of-state position.

Two grants have been made during the year: $50.00 to Kenneth Wagner in connection with a study of the Hepaticae of Indiana; and $100.00 to Dr. J. E. Potzger for a study of bogs in Maine.

Grants in progress or completed during the year: W. E. Martin, in progress; J. E. Potzger, completed project in Michigan; Kenneth Wagner, completed project in Indiana Hepaticae.

The following old grants have been checked and found to be completed: W. H. Headlee, C. M. Palmer, A. H. Meyer, S. S. Visher, I. T. Wilson, P. E. Martin, J. F. Mackell, Winona H. Welch.

Biological Survey. W. E. Ricker reported a continuation of the activities of the committee.

Fifty-Year Index. R. C. Friesner stated that the typing of the manuscript for the 50-year index was completed in January, 1946, and

that the checking of entries against volumes of the Proceedings has been in progress since that time.

Library Committee. Nellie M. Coats, Academy Librarian, presented the following report, October, 1945, to October, 1946:

By exchange arrangement 35 new serial titles were added to the list currently received. Reading Museum supplied several regional ornithological checklists and some items to fill in files of the publications of the Academy of Natural Sciences, Philadelphia, and of the Linnaean Society of New York; purchases consisted of Ohio State Academy of Science Special Paper No. 1 and MacLeay's Descriptive Catalogue of Australian Fishes; three Academy members have responded to the suggestion of supplying the library with copies of their own publications; a few duplicates were sold and a small credit established with the Faxon Company; twelve boxes of duplicates (upon which the State Library paid transportation charges) were given to the American Book Center at Washington, D. C., for shipment to war devastated libraries; the Library mailed the 1944 Proceedings to 872 members and distributed copies to Indiana libraries and to various exchange agencies. There are occasional requests for complete sets of the Proceedings and Miss Coats repeats the appeal that members return their duplicates to the library.

Press Secretary. C. M. Palmer stated that the publicity offices of Indiana State Teachers College and of Butler University have given their time and assistance in contacting newspapers and press associations concerning publication of news of the Academy meetings; copies of Academy program were very helpful in contacting newspaper editors; the photographs of former officers of the Academy, which are kept at the Indiana State Library, are in good condition; the collection includes not only the photographs of the presidents, but, at least for recent years, those of the other officers as well.

Membership. J. E. Switzer presented a tentative report.

Junior Academy of Science. H. H. Michaud, new chairman of the Junior Academy, stated that the 14th annual meeting would be held October 19; records show a total of 53 clubs but only 15 have responded for the 1946 program; the number of inactive clubs has resulted from shifting personnel among science teachers and the unstable conditions of the war years; the committee will attempt to develop the Indiana Junior Academy of Science to its effectiveness of pre-war days. The Executive Committee voted to include the Junior Academy chairman as a member of the Budget Committee.

The Indiana Academy pays tribute to the many years of devoted service that were given by Dean Howard E. Enders to the Junior Academy movement. He not only organized the Junior Academy of Science in Indiana but served continuously and faithfully until this year. His untiring efforts and special interest in the cause of science for children in our schools were responsible for a task well done and deserving of our highest praise.

Relation of Academy to State. F. N. Wallace reported that a request had been made to the State Budget Committee for an increase in our appropriation for publishing the Proceedings and binding our

reports from $1500.00 to $2500.00 per year. Mr. Wallace has been assured the co-operation of the Budget Committee. The committee has made a request also for a sum of $2500.00 for publishing the 50-year Index, this amount to be made available in June, 1947.

Relation of Academy to A.A.A.S. Indiana was represented by Dr. E. F. Degering and Dr. C. L. Porter. Dr. Degering was elected President of the Academy Conference.

Membership Emeritus. Dr. E. R. Cumings, former Head of Department of Geology, Indiana University, was elected to Membership Emeritus.

Nominations Committee. Dr. Degering announced the members of the committee to be T. G. Yuncker, chairman, M. S. Markle, and P. A. Tetrault.

The following members were recommended for election as Fellows of the Indiana Academy of Science:—Jervis M. Fulmer, Chemistry, DePauw University; Dr. Willis D. Gatch, Dean of Indiana University School of Medicine, Indianapolis; Walter G. Gingery, Principal of Washington High School, Indianapolis; Arthur T. Guard, Botany, Purdue University; L. S. McClung, Bacteriology, Indiana University.

Old Business. W. E. Edington reported that the committee on Indiana Men of Science had made real progress in compiling data on History of Science in Indiana.

F. N. Wallace reported that a resolution had been adopted recommending that the matter of an addition to Turkey Run be made or a new park created, taking in the Shades, Pine Bluffs, and some new addition along Sugar Creek.

New Business. J. S. Wright read the following resolutions regarding sale of common stock in Foundation Fund:

WHEREAS the Foundation Fund of the Indiana Academy of Science includes a few shares of the common stock of the Standard Oil Company of Indiana and possibly may receive by gift additional shares of stock in other companies; therefore be it

RESOLVED, that the Trustees of the Foundation Fund be authorized to sell this stock and convert the proceeds into bonds or other securities as comply with rules and regulations governing the investment of the Foundation's funds, the same being those of the Indiana law governing the investment of the legal reserves of life insurance companies; further be it

RESOLVED, that the Trustees of the Foundation be empowered to use their judgment in timing the sale of stock for the best interests of the Foundation Fund.

R. C. Friesner and Scott McCoy were elected to succeed themselves as members of the committee on Bonding of Trustees.

Paul Weatherwax was elected to succeed himself as a member of the Research Grant Committee, term to expire in 1951.

A recommendation was made by the Executive Committee for the publication of the complete membership list in the next Proceedings.

The Indiana Academy of Science recognizes Dr. Martha Doan, Westfield, Indiana, as a member of fifty consecutive years, 1896-1946. The Secretary was instructed to write Dr. Doan a letter of congratulations and recognition. Because of Dr. Doan's distinguished career as scientist and her loyalty to the Academy she was made an Honorary Fellow of the Academy.

Because of the increased costs of printing, the account of the Program Committee has surpassed the amount allowed in the budget. The Executive Committee approved the complete bill.

A nominal sum of $25.00 was recommended for expenditures by H. H. Michaud for the development of the Indiana Junior Academy of Science.

F. N. Wallace suggested that a letter of appreciation of the cooperation of the State with the Academy from Academy members to our Senators and Representatives would be an appropriate deed.

Adjournment, 9:15 p.m.

MINUTES OF THE GENERAL SESSION

INDIANA STATE TEACHERS COLLEGE

OCTOBER 18, 1946

Dean J. E. Grinnell, Indiana State Teachers College, delivered the Address of Welcome. President Degering responded in behalf of the Academy.

W. E. Edington prsented the Necrology.

Minutes of the Executive Committee meeting of October 17, 1946, were read by the Secretary and approved by the Academy.

Following the annual dinner in the Student Union Building Ballroom, J. E. Switzer presented seventy-five applications for membership. The Secretary was instructed to cast an unanimous ballot for the seventy-five applicants.

T. G. Yuncker read the nominations of the committee as follows: *President*, J. F. Mackell, Indiana State Teachers College; *Vice-President*, A. R. Bechtel, Wabash College; *Secretary*, Winona H. Welch, DePauw University; *Treasurer*, W. P. Morgan, Indiana Central College; *Editor*, P. D. Edwards, Ball State Teachers College; *Press Secretary*, C. M. Palmer, Butler University.

The Divisional Chairmen elected in the sectional meetings for 1947 were announced as follows: *Anthropology*, Dr. Erminie W. Voegelin, Indiana University; *Bacteriology*, Dr. Stanley E. Hartsell, Purdue University; *Botany*, Dr. Noe Higinbotham, University of Notre Dame; *Chemistry*, Dr. Alvin Strickler, Evansville College; *Geology and Geography*, Dr. C. F. Deiss, Indiana University; *History of Science*, Dr. C. A. Behrens, Purdue University; *Mathematics*, Dr. J. C. Polley, Wabash College; *Physics*, Dr. B. A. Howlett, Rose Polytechnic Institute; *Psychology* Dr. Alma Long, Purdue University; *Zoology*, Dr. A. E. Reynolds, Depauw University.

C. M. Palmer announced that the Invitations Committee had accepted the invitation from Ball State Teachers College, Muncie, for the 1947 Fall Meeting of the Academy.

Resolutions. Dr. Clyde A. Malott read the following resolution from the Geology and Geography Section, passed unanimously, October 18, 1946:

WHEREAS, the geographic data shown on a standard U. S. topographic map are essential to the study and development of all projects concerning highway construction, drainage and sewerage, flood control, conservation, and all other forms of land use, and,

WHEREAS, such topographic data are basic to the projection of regional, county and city planning now energetically promoted by the Indiana Economics Council, and

WHEREAS, the topographic mapping program in Indiana is far in arrears of that of all the neighboring states,

THEREFORE, be it resolved that the Indiana Academy of Science, meeting at Terre Haute, Indiana, October 18, 1946, petition the General Assembly of the State of Indiana to appropriate the necessary funds to complete the topographic mapping of the State at the earliest date practicable.

Adopted unanimously by the Indiana Academy of Science.

Dr. O. B. Christy, chairman, read the following report for the Academy Resolutions Committee:

The Indiana Academy of Science assembled at Terre Haute, October 17-19, 1946, at its sixty-second regular meeting, expresses its appreciation for the hospitlity extended by the Faculty, Administration, and Student Body of the Indiana State Teachers College. The Academy feels deeply grateful for providing ample food and excellent provisions for the various meetings. Special thanks are offered to the program committee for its efficient work in arranging a program of merit. To these and all others who have helped to make this an outstanding meeting we again express THANKS.

In the absence of the Vice-President, N. E. Pearson, because of a family death, the President, E. F. Degering, was presented by the Secretary, Winona H. Welch. President Degering delivered a very thought provoking address on The Seven Freedoms.

The sixty-second annual meeting of the Indiana Academy of Science, with a general attendance of 250 and a dinner attendance of 150, was adjourned.

WINONA H. WELCH, *Secretary*

ENTOMOLOGISTS MEETING

G. E. LEHKER, Purdue, Chairman

The Entomologists held their meeting Friday along with the Academy sectional meetings. Dr. Arlo Vance, U. S. Department of Agriculture, Purdue University, was elected 1947 chairman.

TAXONOMISTS MEETING

A. T. GUARD, Purdue, Chairman

The Plant Taxonomists held their meeting Saturday morning at Indiana State Teachers College. Dr. R. C. Friesner, Butler University, was elected 1947 chairman.

JUNIOR ACADEMY OF SCIENCE

Officers for 1946

President: CHARLES GIFFIN, Phi-Chem Club, Elmhurst High School, Fort Wayne.

Vice-President: ROBERT REINHOLD, Junior Izaak Walton Club, Central High School, South Bend.

Secretary: ROBERT LOVETT, Science Club, Mishawaka High School, Mishawaka.

Members of the Council: James H. Otto (1942-1946), Prevo L. Whitaker (1943-1947), Roy McKee (1944-1948), Ruth Wimmer (1945-1949), Darl Wood (1946-1950).

PROGRAM OF THE FOURTEENTH ANNUAL MEETING

October 19, 1946

The Laboratory School, Indiana State Teachers College
Terre Haute, Indiana

9:00 A.M. Exhibits in the gymnasium

10:00 a.m. Morning Session

Sycamore Theatre, The Laboratory School

General session, Charles Giffin, presiding.

Greetings, Howard H. Michaud, State Sponsor.

Reading of minutes of 1945 meeting.

"The Family Tree of Birds", Louis E. Wuellner, Technical High School, Indianapolis.

"The Hoosier Trail as a Club Project", (illustrated) Robert Reinhold, Central High School, South Bend.

"Collecting Insects", Bill Kwolek, Lew Wallace High School, Gary.

"A Project Study of the Bacteria", John Repass, Technical High School, Indianapolis.

"Yearly Programs of Club Meetings", John Tuchek, Lew Wallace High School, Gary.

"The Liquefaction of SO_2 Gas", (demonstration) Richard Adams, State High School, Terre Haute.

1:00 p.m. Afternoon Session

Sycamore Theatre, The Laboratory School

"Chalk Talk—Insects", G. E. Lehker, Extension Entomologist, Purdue University, Lafayette.

Business Session—Election of Officers.

Motion Pictures, "Chemistry and a Changing World", "Sand and Flame". (From the film library of the Technical Extension Division, Purdue University).

"The Junior Academy Looks Ahead", Howard H. Michaud, State Sponsor, Department of Forestry, Purdue University.

MINUTES

The fourteenth annual meeting of the Indiana Junior Academy of Science was held Saturday October 19, 1946, in the Sycamore Theatre of the Laboratory School, Indiana State Teachers College, Terre Haute.

The president, Charles Giffin, Elmhurst High School, Fort Wayne, introduced the other officers, Robert Reinhold, vice president, of Central High School, South Bend, and Mary Nasser, State High School, Terre Haute. The latter served as secretary pro tem, due to the absence of Robert Lovett of Mishawaka.

Howard H. Michaud, State Sponsor of the Indiana Junior Academy of Science, and Assistant Professor in Conservation, Department of Forestry, Purdue University, greeted the members of the Junior Academy.

The president opened the meeting by calling for the minutes of the 1945 meeting held in Indianapolis. The minutes were read and approved.

The first number on the program was given by Louis E. Wuellner, Technical High School, Indianapolis, on "The Family Tree of Birds". He gave a very interesting talk on the classification of birds showing how birds were divided according to orders, families genera, and species. By using a blackboard he pointed out special structural differences among birds that are used as a basis for classification.

Robert Reinhold, Central High School, South Bend was called upon next to present "The Hoosier Trail as a Club Project". He explained how the Junior Izaak Walton Club of their school helped to plant trees, provide food and shelter for animals, and promoted other conservation activities on the Izaak Walton League property at South Bend. The special value of their project was for educational and recreational use. Kodachrome slides were used to illustrate his talk. It was presented in a stimulating manner and should encourage other clubs to carry on similar projects.

The president then called upon Bill Kwolek, Lew Wallace High School, Gary, to explain briefly his insect collection which was on display in the exhibit room. He said that his collection contained over

1800 specimens and also told how they were collected, and how his interest in insects began. It was especially noteworthy that Bill said he planned to go to college to continue in some kind of entomological study.

The next speaker called upon was John Repass, Technical High School, Indianapolis, who spoke on "A Project Study of the Bacteria". He used a colored chart showing the types of bacteria, and the methods used in culturing them. The development of new serums for the control of diseases was also discussed.

John Tuchek, Lew Wallace High School, Gary was called upon to speak on "Yearly Programs of Club Meetings". He spoke first of the method of organizing a science club in high school. He also mentioned the different kinds of activities and projects that could be carried on by clubs. Last, he mentioned the important factors that contribute to a successful club.

Russell McDougal, host sponsor, State High School, Terre Haute briefly expressed his appreciation for the cooperation of the various Junior Academy of Science Clubs for making the meeting a success.

The last speaker on the morning program, Richard Adams, State High School, Terre Haute, gave a demonstration on "The Liquefaction of SO_2 Gas". A brief discussion of molecular action and the temperatures of liquefaction and solidifying of different substances preceded the demonstration.

The meeting was adjourned for luncheon at 12:00 noon.

Afternoon Session

The afternoon session was held at 1:00 p.m. in the Sycamore Theatre of the Laboratory School, Terre Haute.

The president introduced Mr. G. E. Lehker, Extension Entomologist, Purdue University, who gave a chalk talk on "Insects". The speaker enumerated several reasons why there are more insects today than there were fifty years ago, and why it is a problem of serious concern today. Not only the talk, but the cartoon illustrations of many insects and insect problems proved very interesting to those assembled.

Business Session

The list of nominees selected by the council was read by Howard H. Michaud, State Sponsor, and the club members ballotted for and elected the following officers for the year 1947: *President*, ROBERT REINHOLD, Junior Izaak Walton Club, Central High School, South Bend. *Vice President*, MARILYN LEECH, Science Club, William A. Wirt High School, Gary. *Secretary*, RAE SAFERIGHT, Science Club, Washington High School, Indianapolis.

Professor Michaud also announced the new council member Mr. Donald Klopp, Shortridge High School, Indianapolis, to succeed Mr. James Otto whose term expired in 1946.

The council announced its choice of Jeanne Hirsch of Fort Wayne and Louis E. Wuellner of Indianapolis as "best girl" and "best boy" respectively, to recommend for honorary membership in the American Association for the Advancement of Science.

The next part of the program included two motion pictures, "Chemistry and a Changing World", and "Sand and Flame", furnished by the Technical Extension Division of Purdue University.

Professor Michaud then spoke on "The Junior Academy Looks Ahead". He urged that we begin planning now for next year's meeting to be held at Ball State Teachers College, Muncie. Several plans were suggested to increase the activities of clubs and to increase membership in the Junior Academy. A news letter was mentioned as a means of informing clubs of Indiana what others were doing. Next year's program should be planned in time to send titles to the sponsor by the end of the 1946-47 school year. Enough papers should be ready so that only the best can be selected for the annual meeting. All of the sciences, especially physics, chemistry, and biology should be well represented to make a well balanced program.

It was also suggested that the Senior Academy committee in charge of the Junior Academy affairs might act as an impartial judge of best boy and best girl qualifications for the honorary award of the American Association for the Advancement of Science.

It was stated that the sponsors and clubs generally needed more information on current source materials in science for classroom and club projects.

About 125 members, sponsors, and friends attended the meeting. The meeting adjourned at 3:30 p.m.

EXHIBITS

Indiana Junior Academy of Science

October 19, 1946

GARY *William A. Wirt High School*

Unusual Insects from Devil's Island, South America by Harold Lundstrom

Lew Wallace High School

Collection of over 1800 Insects by Bill Kwolek

TERRE HAUTE *State High School,* The Laboratory School, Indiana State Teachers College, by Science Club

Faraday Coil
Floating Magnet
Cartesian Diver
Photo-electric Cell

Indiana State Teachers College, by Dr. W. P. Allyn
Snowy Owl (mounted)
Hummingbird in nest (mounted)
Three poisonous snakes of Indiana (preserved)

FORT WAYNE *Elmhurst High School* by the Phi Chem Club
Radio Frequency Induction Heater and Cotton Products Display

RENSSELAER *St. Joseph's College* by Rev. John W. Baechle
Color photos of the Life History of the Cecropia Moth

NECROLOGY

Will E. Edington, DePauw University

Edward William Koch

Lawrenceburg, Indiana — Buffalo, New York
January 8, 1882 — February 9, 1946

The present century has been characterized by tremendous and momentous discoveries that have left no man untouched regardless of whether he realizes it or not. Some of these discoveries like radioactivity, jet propulsion, nuclear fission, insulin and radar have been spectacular and have come out of the laboratory. Not so spectacular but certainly as fundamental have been the discoveries in preventive medicine, sanitation, genetics and surgery, that have led to greatly increased longevity and the virtual extinction of many epidemics common in the past. These have come about through the tremendous expansion in size and standards of medical schools and hospitals, and specializing clinics and laboratories devoted to definite but limited fields of study. From these institutions has come a steady flow of young men and women highly skilled and efficient in administering to and alleviating the ills of suffering mankind. Edward William Koch, Dean of the Medical School of the University of Buffalo for sixteen years and Dean of the Dental School for a shorter period, was one who has done much during the past three decades to raise the standards in medical training and to instill in medical students of his University the ideals of the Hippocratic oath.

Edward William Koch was born on January 8, 1882, at Lawrenceburg, Indiana. After finishing the common schools he entered Indiana University where he remained two years. He then returned to Lawrenceburg to teach science in the high school, succeeding Willis D. Gatch who later became Dean of the Indiana University Medical School. After three years of teaching he reentered Indiana University, received the A.B. degree in 1908 and the A.M. degree a year later, serving in the meantime first as an assistant and later as a teaching fellow in physiology and pharmacology. Entering Rush Medical College he became an M.D. two years later. Following two years of interneship at the Presbyterian Hospital in Chicago and the Akron City Hospital, he returned to Indiana University as an instructor in physiology and pharmacology and taught two years. In 1915 he joined the research staff of the Eli Lilly Company and spent the next three years experimenting with the ipecac alkaloids. Exposure to these drugs effected his health and he accordingly accepted the professorship of pharmacology,

in 1918, at the University of Buffalo Medical School, where he remained until his death on February 9, 1946.

The fine executive ability of Dr. Koch was immediately recognized at the University of Buffalo for he was made Secretary of the Medical School the year of his arrival. After ten years in this capacity he was made Acting-Dean, and two years later, in 1930, he became Dean of the Medical School. In 1936 he was also made Dean of the University of Buffalo Dental School, which duty he performed until 1944. He was not a well man during his last five years, but he was never known to complain.

Dr. Koch was an earnest and conscientious teacher and a sympathetic, progressive and efficient executive of sterling integrity who maintained the respect, loyalty and cooperation of his students and colleagues. While his executive duties precluded his doing much research, he nevertheless held research in the highest regard and encouraged it wherever possible by using his influence to secure funds for equipment and apparatus. He was the author of a half dozen papers on medical subjects and joint author of three other papers based on the results of his pharmaceutical work with the Eli Lilly Company.

He was a Fellow of the American Medical Society and of the American Association for the Advancement of Science. He also held membership in Sigma Xi, Alpha Omega Alpha and Nu Sigma Nu, the latter two being Honor medical societies. He joined the Indiana Academy of Science in 1914, while an instructor at Indiana University, and was made a Fellow three years later.

Dr. Koch retained his love for Indiana throughout his life. His philosophy of life was kindly and penetrating with a fine sense of humor. He loved to quote Riley, George Ade, Will Rogers, and Kin Hubbard's Abe Martin. Modest and unassuming, tolerant and gracious, never sarcastic, he endeared himself to those who knew him. He was widely known in the medical profession where his contributions to his chosen field are recognized as real and enduring.

RALPH MESCHTER KRIEBEL

Hereford, Pennsylvania — West Lafayette, Indiana
October 12, 1897 — March 15, 1946

With the death of Ralph M. Kriebel on March 15, 1946, the Academy and the State of Indiana lost a true naturalist and a real conservationist. He had steadily built up a reputation as a leading conservationist in this and neighboring states, having served for two weeks annually from 1939 to 1945 as a teacher in the Ohio Conservation Laboratory sponsored by Ohio State University and the Ohio Department of Conservation, and also for two years in a similar Tennessee teacher training conservation program. His wide knowledge of agriculture, its soil, plants and animals, enabled him to speak with such authority that he was in demand as a lecturer before schools, youth camps and various garden, nature study and conservation organizations.

He was born on October 12, 1897, at Hereford, Pennsylvania, and received his basic education in Perkiomen Academy at Pennsburg, Pennsylvania. He then entered Muhlenburg College, and completed his education at Valparaiso and Columbia Universities. He taught science for one year in Perkiomen Academy and then came to Indiana where he taught science and coached for three years in Kentland High School. He spent seven years as a stone carver and sculptor for the Indiana Limestone Corporation. Joining the United States Conservation Service in 1935, at Bedford, as a biologist and farm planner, he came into contact with the leading botanists, naturalists and conservationists of the State. His fervor and skill in plant collecting had already attracted the attention of Dr. Charles C. Deam, and they became fast friends, the younger man deriving inspiration and insight from the Dean of Indiana botany. At the time of his death Mr. Kriebel had built up one of the best collections of plants of the State in Indiana.

He joined the Indiana Academy of Science in 1933 and his first Academy paper appeared in the *Proceedings* for 1934. He published a number of papers on taxonomic botany and conservation. His best scientific work was done in taxonomic botany, and he appeared regularly before the Botany Section of the Academy and the State Society of Taxonomists. From 1940 until the time of his passing he served as a member of the Academy State Flora Committee which kept Deam's *Flora of Indiana* up to date, the reports appearing annually in the *Proceedings*. He served as Chairman of the Taxonomists in 1938, and as Chairman of the Academy Botany Section in 1940. The Academy elected him a Fellow in 1938.

In 1943 he came to Purdue as an extension soil conservation specialist employed jointly by the University and the United States Department of Agriculture, and he served with distinction up to the time of his death.

He was a member of the American Association for the Advancement of Science, The American Society of Taxonomists, The Wildlife Society, The Society of American Foresters, The Indiana Audubon Society, and The Indiana Soil Science Society.

"It is impossible for laymen to capture in phrases the spirit that motivated and characterized Ralph Kriebel. His infectious enthusiasm for teaching and preaching all forms of conservation arose from his vivid realization of the unity of man and his environment and from a genuine love of nature." Ralph Kriebel was a scientist in the truest sense of the word and his untimely death is a real loss to the nation.

VINCENT ANTHONY LAPENTA

Naples, Italy
July 4, 1883

Indianapolis, Indiana
April 20, 1946

America owes much to Europe for its scientific and cultural development, and until the present century might be considered a scientific

debtor. This was particularly true in such fields as physics, chemistry and medicine. However, the tremendous industrial developments and intensive exploitation of our resources have resulted in such accumulations of wealth and such standards of living that through philanthropy, state and federal taxation, and the industrial laboratories, America has developed great medical and scientific foundations. Leading European scientists have been induced to come to America and others attracted by the opportunities have come and by their talents have made notable contributions to America's scientific development. One of these latter was undoubtedly the young surgeon, Vincent Anthony Lapenta, who came to the United States in 1907.

He was born in Naples, Italy, on July 4, 1883, and received an Italian education leading to the M.D. degree from the University of Naples in 1906. Following his arrival in the United States he continued his studies at the Harvard Medical School in 1910 and the Illinois Postgraduate Medical School in 1911. He came to Indianapolis in 1911 and began the practice of abdominal surgery. Later he became associated with St. Francis Hospital, in Indianapolis, and was chosen President of its Staff in 1925, and Surgeon in Chief in 1929, and he continued active in this work up to the time of his death.

Dr. Lapenta was deeply interested in chemistry, particularly in its applications to the problems of surgery. In 1917 he made his capital discovery of his Neo-Hemoplastin Serum for the control of hemorrhages, in recognition of which Great Britain conferred upon him in 1922 the honor of Fellow of the Royal Society of Arts and Sciences. His serum has been produced and marketed throughout the world since 1917 by the Parke-Davis Chemical Laboratories, and Dr. Lapenta was a Consulting Biological Chemist for this company for a number of years. He was the holder of five other patents for medical methods and apparatus. He was a regular contributor to the leading medical journals on problems of surgery and the various unusual cases that came under his observation. On account of his scientific achievements his native Italy decorated him in 1939 with the honor Knight Commander of the Order of the Crown of Italy. He had also served as the Italian Consul in Indiana for a number of years. Dr. Lapenta was also recipient of the decoration of Knight Commander of the Order of the Crown of Roumania.

He was a member of the Gorgas Memorial Institute and a Fellow of the American Medical Association. He was a member of the Executive Council of the International College of Surgeons, an ex-Chairman of its Board of Examiners and a former Chairman of its Editorial Board. He held membership in various national and state medical and pharmaceutical societies as well as in the American Association for the Advancement of Science. He had been a member of the Indiana Academy of Science since 1931 with his interest in chemistry and bacteriology. His hospital duties had prevented his active participation in the work of the Academy, since many of its meetings are held outside Indianapolis.

Dr. Lapenta was not only a fine surgeon and mender of broken bodies, but also a man of broad and tolerant outlook. It was necessary

to know him over a number of years in order to appreciate his personality and to become aware of his patience and kindness in the performance of his duties. The Academy and the State of Indiana should be proud of and grateful for the service rendered to humanity by this great surgeon.

JOHN LYMAN SHEEAN

Superior, Wisconsin — Ashland, Wisconsin
November 27, 1894 — April 5, 1945

John Lyman Sheean was Professor of Chemistry and Dean of Men at Northland College, in Ashland, Wisconsin, at the time of his death on April 5, 1945. He was born on November 27, 1894, in Superior, Wisconsin, and after completing the work of the common schools, he entered Macalester College and received the B.S. degree in 1916. He did graduate study at the University of Minnesota in 1923 and in Carnegie Institute of Technology in 1926-27. Following his graduation he was chemist for the United Lead Company in Iowa for four years and then took employment with the Fairview Fluorspar Company in Illinois for a year. In 1924 he went to the Carnegie Institute of Technology as an instructor in chemistry in the College of Engineering where he remained four years. In 1928 he accepted the headship of the Department of Chemistry at Culver Military Institute. He was at Culver three years and then took a position with the Mosanto Chemical Works near Saint Louis. In 1933 he was called to Northland College. However, he maintained a permanent home address at Cloquet, Minnesota.

Mr. Sheean was a very conscientious and effective teacher who vitalized his chemistry teaching with the project method wherever possible. He believed that the method of projects greatly stimulated the student's interest and also helped to equip him for more efficient living and employment, but he considered the project method only as an adjunct to the fundamental laboratory and recitation work. He used these methods with success at the Culver Military Institute and reported on his results at the meeting of the Indiana Academy of Science in 1930. He was the author of several papers on the teaching of high school and college chemistry. He also published one paper on the beginning of electro-chemistry activity and another paper on the History of Chinese Pottery.

Mr. Sheean was a member of the American Association for the Advancement of Science, The Electro Chemical Society, and the American Association of University Professors. He joined the Indiana Academy of Science in 1930, but as he left the State the following year he was not well known to many Indiana scientists. He presented two papers before the Chemistry Section in 1930, one of which was published in the *Proceedings*.

MILTON M. WILLIAMS

Piketon, Ohio — Bloomington, Indiana
November 3, 1880 — April 14, 1946

When the Junior Academy of Science was founded in 1931, one of the charter clubs was the Bloomington Junior High School Club. Its sponsor was Milton M. Williams who continued as its sponsor for the next fifteen years. When the Junior Academy was first organized the officers were chosen from the sponsors and this plan was followed for several years. Mr. Williams was President of the Junior Academy in 1933-1934. At the Fall Meeting in 1934 he presented a plan for a State Constitution for the Junior Academy, but action was not taken that year. He continued to be very active in the work of the Junior Academy and regularly brought members of his Club to the meetings where they presented papers and exhibits. At the meeting in 1939 he gave an address on "What Makes a Live Club."

Mr. Williams was born on a farm near Piketon, Ohio, on November 3, 1880. He came to Bloomington in 1904 to enter Indiana University and was graduated in 1908. While a student in the University he worked during spare hours in the Whetsell Shoe Store, and following his graduation he married Mr. Whetsell's daughter, and at Mr. Whetsell's death a few years later he operated the store as manager. After some years he entered the teaching field and taught for a time at Ellettsville. In 1930 he became a science teacher in Bloomington High School, which position he still held at the time of his death from a heart attack on April 14, 1946.

Mr. Williams was deeply interested in science teaching and was very successful in arousing the interest of his pupils in science work. Some of the exhibits presented by his pupils at the meetings of the Junior Academy were unusually fine and reflected great credit on Mr. Williams. He was a lover of flowers and followed flower raising as a hobby. At one time he had quite an extensive collection of cacti.

The Junior Academy of Science owes a great deal to Mr. Williams for its success, for he pioneered in its work and was most faithful and effective in his cooperation with Dean Enders, the Senior Academy representative. He also influenced a number of young men and women to continue their science study in college and thus his work will continue to live.

The Seven Freedoms

Ed. F. Degering, Purdue University

Since the first appearance of the human race upon this globe, man has been in quest of an evasive, indefinable something which we call freedom. The pages of history have been dyed with human blood and that without the attainment of the ultimate objective. Today we find ourselves, according to H. G. Wells, in a strenuous race between civilization and catastrophe, with catastrophe threatening momentarily to overtake civilization.

Throughout the centuries our forefathers have struggled for freedom of worship. We, too, are committed to that struggle. In terms of the lives of one and one-half billions of people, the goal is still far from attainment. Millions are still clamoring for the right to enjoy freedom of worship.

Freedom of speech is another star on the horizon of idealism which has been followed throughout the centuries. At times it has shown forth in all its splendor but again it has appeared only as a tiny speck of light in the distance. Today its radiance is obscured both from without and from within: both from action and inaction. Far too many of the teeming millions who are following this star are doing so by proxy. They are content to let others speak, write, and vote for them. The politicians speak whereas the masses, including the scientists, remain silent. Undoubtedly there is no group better qualified to analyze the mess and to reason from cause and effect than are the scientists, yet they seem content to let someone else express their views and cast their ballot. They are too engrossed with the problems of today to think about those of tomorrow.

According to the *American Scientist* (Scientists Should Knock at the Door of American Politics, p. 87, by Morris Llewellyn Cooke): Scientists will be the first to admit that all is not well in the current relations between science and politics. There is little understanding on either side. To put it bluntly, the politician largely ignores the scientist, and the latter all but despises the politician.

"Science is at an all time peak performance. In fact our technological advance has become so rapid that unless we drastically alter some of our social and political concepts and the institutions through which they are given expression, technological achievements by their misuse may be our undoing. In spite of the glamorous accomplishments of science, it is apparent that the spectre of dire and growing want in the midst of potential plenty exists for the greater part of humanity. For fast-moving progress along a broad front, the active and comprehending cooperation of politicians is absolutely required. So if there is anything

which scientists can do to woo and win the politicians, it will have tremendous social significance. But it will be futile to knock at the door of American politics unless we come equipped with both understanding and sympathy. Some common ground between the two areas must be found. This, however, should not be too difficult.

"Whether we like it or not—and some technologists do not like it at all—we are part and parcel of a community life which grows more complicated day by day, with increasing interdependence of the various factors and an ever-mounting toll which the public pays for inefficient or anti-social management of these public and semi-public affairs.

Bernard M. Baruch recently said (*Lafayette Journal-Courier*, p. 1, Oct. 9, 1946) that on the question of principles, "it is an inalienable right each of us has to express an opinion on every policy animating this country, whether national or international. This is the highest function of those who live under a political democracy; of those who cherish the right of free speech. Every man has the right to an opinion but no man has a right to be wrong in his facts. Nor, above all, to persist in errors as to facts."

It is in reality the attitude toward facts which is the principal cause of dissension between the politician and the scientist. Quoting from David E. Lilienthal (*The Chemical Bulletin*, p. 411, October, 1946): "Political methods—I am over-simplifying a bit, but not much—are based on three procedures, so far as the people are concerned, as follows:

"First: Tell the people what you know they want to hear—regardless of the facts. This gives great scope for orators, slogan-makers, and dogmatists.

"Second: Tell the people what *you* want them to hear—regardless of the facts. This is the technique of the well-poisoner.

"Third: Tell 'em nothing, and make 'em like it. This is an ancient art, but its modern practitioners have brought it to a new high level.

"Political methods are generally quite in contrast to the scientific spirit and method. In his *Novum Organum*, Francis Bacon said many, many years ago: 'We cannot command Nature except by obeying her.' The scientist, essentially a humble man, obeys Nature by honestly observing and then truthfully recording *not* what he *wants* to find, but what in truth he *does* find."

The entire world today is clamoring for freedom from want, yet there has never been a period in the history of the world when the sum total of wants were greater than they are today. Not only are the wants of the world today greater than ever in the history of the past, but our capacity for taking care of these wants seems more remote than ever before. We find ourselves in the position of the blind man on a dark night in a dark alley looking for a black cat that isn't even there. The Nations of the world found themselves well prepared to arm, equip, feed, and clothe the greatest fighting forces ever known to mankind, yet these same nations find themselves totally incapable of feeding and clothing the millions who survived annihilation. Whither are we

bound? Are we adrift on the chaotic seas of life without chart, helm, or anchor?

Closely associated with the freedom from want is the freedom from fear. Fear has always reigned supreme throughout the annals of history. The hour is far past for the replacement of fear with some good, clear, sound thinking. Since our forefathers landed on the rock-ribbed coast of Maine, "we, the people" have engaged in wars of one type or another to the amount of about 414 billions of dollars. This represents approximately 114 billions more than the total worth of the United States. We are in the red, in other words, to the sum of 114 billions of dollars because of some type of fear or another.

Quoting from *The Catholic Hour* of September 8, 1946: "Other nations fear American monopoly of atomic weapons and are doing what they can to offset it. Nations which suspect American preparations for a future war seek to do likewise and to engage in unilateral activities directed allegedly toward their own national security. A vicious circle in suspicion and armament continues to produce distrust and fear.

"Unless the suspicion and hatred now existing and increasing among the Great Powers is soon terminated and unless the competition in armaments soon ceases, the world is headed for a third world war."

If World War III does come, and come it must unless someone comes up with an opiate for fear, we will have to revert to the stone age and live with the ants in caves and subterranean homes, villages, and factories. To go under ground, according to reliable estimates, would cost the United States approximately 300 billions of dollars. Add this to what we have already spent on wars, and you have a per capita fear-complex cost of approximately $5,000 or about five times the per capital net worth of the United States. Once again I ask, whither are we bound?

Next we come to a consideration of what has been called the freedom of economic enterprise—the right to earn a dollar and the right to spend that dollar. Today there is some question as to whether or not either of these rights actually exist. Either politics or society or both have become so complex that almost everything is run from the top and the individual has become a mere cog in a Frankenstein innovation which threatens to deprive him of his last iota of individual initiative. One is told when to go to bed and when to get up, when to work and when not to work, when to plant and when to reap, what to plant and what to reap, when to build and when to tear down, and even when to rejoice and when to weep. We have been beset from within and without with economic planning which savors too much of planning and not enough of sound economics.

In an address before the National Highway Transportation Congress, on September 26, 1946, Alfred P. Sloan, Jr., chairman of General Motors Corporation, said: "Today the automotive industry is beset by all manner of limitations. It is not what we would like to do, what we had planned to do, or expected to do. It is what we are permitted to do.

"Indifferent workers take the place of effective workers. Work stoppages take the place of continuous operation. Absenteeism takes the place of full service. Naturally it does not work.

"And then some wonder why we are in such a mess and we certainly are in a mess at the moment. Our opportunities for accomplishment were never greater, on the one hand, and the obstacles against some progress never more discouraging, on the other."

The sixth item is freedom from prejudice. Turn to agriculture, business, creed, economics, labor, politics, race, religion, science, social welfare, or where you will, and you find the situation bemuddled by all types of prejudice. How can we hope to have freedom of worship, freedom of speech, freedom from want, freedom from fear, and freedom of economic enterprise until we have freedom from prejudice. Perhaps it can be said without exaggeration that half of the world moves on the wheels of prejudice.

This freedom from prejudice has a special application here and now. The scientist, with his head above the stars because of scientific achievement, has his feet often times wallowing in the mire of scientific prejudice. Wöhler, in 1824, stewed up some lead cyanate with ammonium sulfate and four years later discovered, because he was free from the vital-force stench of scientific prejudice, that he had synthesized urea. Likewise Perkin in 1856, because he was willing to accept the answer of the test tube rather than adhere to some preconceived notion which was based on erroneous postulates, effected the first preparation of a synthetic organic dye. It is of interest to note that he was motivated by the additive theory, that he had not purified his starting materials, that his technic was mediocre, and that he did not even know the formula of quinine, which he was attempting to synthesize, yet he came up with one of the strikes of the century because he possessed, to some degree at least, freedom from jrejudice.

Coming somewhat nearer home with respect to both time and place, one of my graduate students in 1932 was attempting to condense silicon tetrachloride with diethylzinc to yield tetraethysilicon. This work was undertaken because a friend of Purdue University at the Indiana Refining Company wished to test tetraethylsilicon as an anti-knock fuel. Our final product, accordingly, was predetermined. We knew what the answer to our experiment should be. We had a scientific prejudice. It is not surprising, therefore, that the greyish, gummy mess which was obtained (now known to be of the silicon type) was consigned to the sink as a scientific abortion.

I recall, somewhat more graciously, an attempt by one of my graduate students to condense ketene with nitromethane. Repeatedly, he bubbled ketene through nitromethane in the presence of various catalysts with negative results. It then occurred to us that the use of a solvent such as acetone might facilitate the condensation. After more attempts and failures, three milliliters of a product was obtained. This product, however, was not the anticipated derivative and might well have been consigned to the sink except for the fact that we did not care in this case what the test tube gave us. As a result we put ourselves to the task of finding out what the experiment had yielded and thus discovered that we had effected the synthesis of isopropenyl acetate (methylvinyl acetate), which proved to be a very important monomer for synthesis

of the Lucite type of plastic. Some of your purchases in the near future will be tied up in some way or another with this new monomer because we were willing to accept the result of the experiment—we were free from scientific prejudice.

According to the *AAAS Bulletin,* this is a time calling for scientific statesmanship, as well as for eminent specialists, for wide horizons, as well as for penetrating insight into special problems.

The last item to consider is freedom for research. The Fulbright bill, S. 1248, favorably reported by the Senate Committee on Commerce, was introduced by Senator Fulbright, former president of the University of Arkansas, to establish a Bureau of Scientific Research within the Department of Commerce. The announced purposes of the bill are:

"1. To promote in the national interest the fullest and speediest introduction of new techniques in science and invention and in manufacturing, communication, and other phases of production activity.

"2. To promote the maintenance of free enterprise by making available to small and medium-sized business, scientific and technical inventions, products, and processes.

"3. To establish a central scientific and technical office to assure maximum use of new inventions, products, and processes.

"4. To aid, encourage, and protect the research and enterprise of inventors, scientists, technicians, scientific and educational institutions, and research laboratories engaged in scientific and technical work, and to make their resultant discoveries and data more readily available, without discrimination, to all sections of industry, agriculture, and the public in order to promote full employment and higher standards of living.

"5. To compile and maintain a comprehensive inventory of the findings and other pertinent data resulting from federally financed scientific research and development, and of other information on scientific and technical advances in this country and abroad, and to make available to the public."

The research program of the Navy and its relation to educational institutions was outlined this morning by Captain Lawrence. This affords an opportunity for educational institutions to receive funds for fundamental research along their own particular lines of endeavor. Then too, for those who are particularly interested, carbon 13, ranking in importance with x-ray as a tool of medical science, is to be made available by the Houdry Process Corporation without cost to qualified noncommercial biological and medical research organizations. The use of C-13 may be compared to a chemical microscope, making it possible to follow chemical reactions in the body, and has already been used successfully to show how fats are broken down, a process about which science has hitherto only guessed.

A healthy research program in the colleges and the universities, moreover, is an excellent way for these United States of America to maintain scientific leadership. Such leadership seems to be intimately tied up with national safety. We cannot hide behind the atomic bomb.

Quoting from *Chemical and Engineering News* (24, 500, Feb. 1946): "Foreign missions in the USSR reported to their governments February 1 that Soviet scientists had succeeded in splitting the uranium atom. Konstantin Petrozhak and Georgi Floryov on January 27 divided a second prize in the distribution of Stalin Awards for 'discovery of the occurrence of spontaneous disintegration of uranium', hailed as 'one of the greatest achievements in Soviet physics in recent years'. The significance of the announcement is that the work is said to have been done in 1943 and 1944."

All too frequently in the teaching profession, the research motive withers and dies because of lack of encouragement, equipment, help, and time. This must not and cannot be. Research must go on, and research in educational institutions must assume a more important place in the total research program than ever before. Any teacher becomes a better teacher if he is inspired by the research motive. The times demand that we do the best teaching possible, and that in turn demands that teachers in colleges and universities, and in certain instances even in high schools, be given the opportunity, facilities, help and time to do research. I submit then these seven freedoms, but the greatest of these with respect to the program of the Indiana Academy of Science, is freedom for research.

The Uniform Turns To Science

Captain M. J. Lawrence, U.S.N. Assistant Chief,
Office of Naval Research

Last March in St. Louis Admiral Bowen and I had the pleasure of addressing the American Association for the Advancement of Science. Shortly after that meeting your president requested one of us to speak at the fall meeting of the Indiana Academy of Science. It is with a great deal of pleasure that I accept. It gives me an opportunity to explain, at least from a naval point of view, why the uniform needs all of the assistance it can get from you men representing all fields of science.

By way of review, on May 19, 1945, the Secretary of the Navy acting under the War Powers Act established in his Office the Office of Research and Inventions. In August of this year the President signed a bill creating by law and permanently establishing the Office of Naval Research. Admiral Bowen was appointed the first Chief. I am one of his Assistants. Hereafter I refer to the Office of Naval Research instead of the former Office of Research and Inventions although the personnel and ideals are the same.

Before we get too involved, let me frankly state that there is nothing spectacular in this talk. My Office does not subscribe to this so-called "Buck Rogers" thinking. We are interested in fundamentals, and cold, sound basic facts which you gentlemen can provide for us.

The atomic bomb, guided missiles, supersonic air speeds, and all the fantastic developments of modern war have created an intense interest in scientific work in human minds throughout the world. The man in the street is interested in science as never before. The man in uniform is vitally interested, not only through curiosity, but because he feels that the future safety of the nation depends on maintaining a close working partnership between the Navy and the best scientific minds available in this country.

Therefore, the uniform has turned to science because the tremendous scientific achievements of the past few years have put us in a position in which we are unable to protect our country without scientific help. We ask for a partnership with science because we cannot protect our people, our resources, and our industry unless such a cooperative venture is established and maintained.

Not only do we know that the nation's safety depends on the uniform keeping ahead in scientific knowledge, but we also know that we in the Navy are the ones who will be called upon to operate the creations of that knowledge.

Push-button war is, I believe, an unfortunate term because it gives the layman the idea that modern war is a simple affair. Guided missiles, rockets, and jet engines are complicated devices which only highly skilled technicians and trained engineers can operate.

The day is past when a few specially educated and qualified officers could operate the fleet with the assistance of crews distinguished more for brawn than brains. The Navy of today must have alert, nimble-witted and better than average educated men in all ranks. The training and direction of such high caliber men will require leadership of the highest degree.

It is not necessary to define to this audience the words "basic", "applied", and "development" used in scientific work. We break a project into three parts: first, the search for new facts; second, the assembling of those facts to a point where something might result and; third, the development or the engineering phase to produce a piece of hardware. The first and second are the concern of the Office of Naval Research while the latter, the engineering phase, normally falls to the large material bureaus in the Navy.

Assume, for instance, that we want to know more than we do now about the energy level spectra of radioactive nuclei. The Navy, with all its facilities, is not equipped to undertake such research work, and does not have the Nation's outstanding experts in science in its organization. Therefore, we make a partnershp agreement with, let us say, Professor Alan Mitchell of Indiana to undertake this work. The contract states, in effect, that the research facilities and brains of Indiana University will be put to work on the particular project under discussion, and that Navy funds will finance part of it on a non-profit basis, that progress reports will be sent to the Chief of Naval Research, and that findings may be published, if desired, through the usual scientific channels. Remember that we look upon these contracts as partnership agreements.

In other words, we do not want to control research. We want research to be free and untrammeled, unhampered by restrictions of military security, or any other restrictions, free to pursue new knowledge in the researcher's own surroundings, where, by his own choice he can work best, and where his associates and associations are adapted to his special needs.

In actual fact, the vast majority of our contracts were proposed to us by the representatives of universities and not by us to them. As of October first the Office of Naval Research had over 90 basic contracts, more than 70 of which are with universities or other private concerns, the whole representing over 200 different research tasks. The contracts and research tasks range through the fields of nuclear physics, electronics, mathematics, geophysics, flight, propulsion, chemistry, medical sciences, physics, mechanics and materials.

In Medical Science, tasks range through all the basic fields such as Protein Synthesis, Effects of Irradiation on Animal Tissues, Nutrition, Cancer Research, Rehabilitation of the Blind, Diet in Mouth and Tooth Deteroration, Isotope Research, Phychology, and many others.

It is easy for us all to see that a broad research program in medicine is not going to be limited in its benefits to Naval personnel alone. I hope that I will be here five or preferably ten years from now so that I can say, "I had some small part in that program," because I feel that the research partnership sponsored by my Office in medicine is going to be of inestimable benefit to humanity over all the earth, regardless of uniform, race, creed or color.

One of the important and interesting programs of the Medical Branch has to do with the Polar regions. Much work has been done in tropical medicine but little attention has been paid to the territory of the North where living conditions are as unusual and different from the major areas of our country as are the tropics.

One of the most urgent needs at the moment is the assembling all of the knowledge of the Polar regions into appropriate centralized form. An encyclopedia of the regions is being compiled. A master list of persons who know enough about the Polar regions to be classed as experts is being assembled.

We must obtain the basic knowledge needed to develop medical techniques, correct diets, efficient clothing, housing, and the other human needs peculiar to this tremendous section of the world. Any basic information which we obtain will be available to anyone in our country who can use it.

In some fields, other than medicine, the connection between benefits to people as a whole and the military are not so apparent, but a little reflection on the past turns up many such connections. It was basic research in radio wave propagation undertaken by the Naval Research Laboratory and others in the early 1920's, which led to long-distance high-frequency radio broadcasting which now gives us round-the-world on-the-spot newscasting. Going back further, the need for a domestically produced armor plate, led to negotiations between the steel industry, and the Navy with a subsidy for research and development being granted in 1881, which, of course, was a start toward the opening of our enormous industrial expansion.

If, in the future, metals or plastics are developed through Naval research that will withstand temperatures now unheard of, those materials will benefit civil enterprise in the same way they do the military. Lighter weight power plants improve the efficiency of industrial machinery quite as much as they do the Navy's. It may well be that the advances in atomic energy uses and the discovery of new properties of metals will of necessity go hand in hand. Without science we cannot expand the frontiers of new knowledge.

Let me briefly indicate some of the projects underway here in the middle west. At Notre Dame, the rearing of germ-free animals being done by Professor Reyniers, and grain growth in metals by Dr. Beck; at Chicago, high speed X-ray technique by Dr. Hodges; at Illinois, studies on high blood pressure by Dr. Wakerman, studies of aromatic fluorides by Dr. Reed and Dr. Finger, metal fatigue and critical studies of methods of selecting materials by Professors Wilson, Dolan and Newmark; at Ohio State University, investigation of new high calorimetric

methods; at Michigan, mathematical studies in connection with guided missiles work by Drs. Kaplan, Copeland and Thrall; at Northwestern, psycomotor skills by Dr. Seashore, fundamental work on basic differential equations by Dr. Stutzman; and at Purdue, studies in jet propulsion. There are many more about to get underway which would take several pages to enumerate.

Looking ahead to next year the program will go into studies of inorganic, high energy fuels, as well as the physics and chemistry of surfaces. We want to know more about sun spots. We want investigations to determine heat transfer coefficients and related problems at high Mach numbers and the studies of the fundamental mechanical properties of solids in terms of the forces between component atoms. We want a broad theoretical nuclear research program based on the study of elementary particles and their interactions, the study of nuclear reactions, and the study of the structure of the various nuclei. We need to know more about acoustics, especially ultrasonics. These are only a few of the future plans and needs.

You have probably been wondering how the small college can participate in this research program we have been discussing. An examination of the program will show that we already have both large and small colleges participating. In some cases, the larger institutions were ready sooner than the smaller. We have avoided paying for facilities except where such a facility did not exist in the country, or where what few there were, were heavily over-taxed. We have always desired to place several speculative projects in untried or untested places. We feel the gamble would yield results. It would certainly include the small colleges. The small college can also take advantage of sub-contracts with larger neighboring institutions, since the large university may need facilities and personnel to assist them in certain phases of a program. Such arrangements are better for the small school because the business arrangements can be made simpler for them than by dealing direct. It may well be that the small school faculties can get a far broader picture of over-all problems by devoting part of a year to a personal service contract with our Office. I guarantee their vision will be broadened and their thoughts stimulated. The furnishing of ideas is another method of helping. True, it may not be remunerative, but it can be of service to science. The facilities at the small colleges may not be adequate. The staff may not be adequate and yet I know from experience that each of you scientists obtains a great deal of professional satisfaction if you can present an idea and have it worked on even if by someone else. The important thing is to get the knowledge out where it can be used. I will mention another method, that is, to constantly pressurize the high schools to provide adequate science facilities for the young high school student.

The war, unfortunately, had the effect of depleting our reserve of scientific manpower. Dr. Vannevar Bush in his report to President Roosevelt entitled "Science—the Endless Frontier," puts the present deficit in trained scientists at 18,000.

The Office of Naval Research is of course vitally interested in remedying this deficit of trained research workers. Recently, working through the Science Service Organization there were selected in five major cities 110 high school students who showed promise as future scientists or were outstanding students. These boys were given trips to air stations and a cruise out to sea for a period of four days. This was a program of encouragement, not to join the Navy, but to adopt a scientific career in order to build up our scientific deficit.

Strange as it may seem we found that we did not have to provide an incentive to become interested in science. The complaint of the boys themselves was about their schools and the science courses being offered them. I point out to you men and women a great many of whom are in the educational field, that you must take the lead and see to it that the high schools in this area have appropriate scientific courses for those boys who have a scientific bent. Some day they will become your students and only by giving them the opportunity that they ask can we hope to build up sufficient numbers of scientists in this country.

The Academy is particularly suited to lead in this important field of service. Indiana is fortunate in having a distribution of highly reputed colleges which blanket most of the State. These colleges are not only centers of formal higher education but exert wide influence on the diffusion of knowledge to the total population of the area they serve. Three methods occur to me by which your colleges may stimulate the improvement of science instruction in secondary schools and larger enrollments in science courses. These methods are not new. They are: first, the Science Day at each college; second, meetings for high school science instructors; and third, the Science Club movement in secondary schools.

A number of colleges have found that a Science Day for high school students and their parents makes the challenge of science real and personal to them and provides an incentive to young people to embark upon the serious study of science.

We all recognize that the level of science instruction in secondary schools needs to be greatly raised. Local colleges can make a direct and immediate contribution in this direction by arranging occasional meetings for high school instructors three or four times a year. At these meetings the problems of teaching high school science can be discussed, simple demonstrations presented of the type which these instructors can use in their own classes with the equipment available to them, and demonstrations and lectures on some of the newer developments in science which will stimulate these teachers to more adequately prepare themselves with graduate study in science fields.

The Science Clubs of America movement offers a means of keeping high school students actively at work in the study of science and the pursuit of science hobbies. These clubs can be fostered by Academy members and the science facilities of the colleges of your State, by furnishing speakers who may be faculty members or graduate students, by loan of exhibits, models, demonstration kits, motion pictures and the like for use in science club meetings.

The Office of Naval Research is particularly interested in cooperating with the Academy of Science in doing what it can to assist in this important project of attracting the best young minds to careers in science, and aiding the colleges to develop these young people into our most able research scientists of tomorrow.

We are also interested in the fastest way to train men, to what type of appeal does the mind most readily respond, and why? Also, what qualities of mind and body contribute to leadership? Ohio State University is doing research work on leadership under a Navy contract, the results of which should prove of interest to executives in all walks of life since the need for leaders is certainly not restricted to the Navy.

Is the uniform dominating science? Far from it. By law the Navy has a Research Advisory Council composed of outstanding scientists, ten of whom have been appointed by the Secretary of the Navy. They are Dr. L. A. DuBridge, Drs. Karl T. and Arthur H. Compton, Mr. Richard J. Dearborn, Dr. Detlev W. Bronk, Dr. William S. McCann, Dr. Philip M. Morse, Dr. Warren Weaver and Rear Admirals Lewis Strauss and Luis de Florez, U.S.N.R., now on inactive duty. It held its first meeting in Washington on the 14th of this month. This Committee will assist in coordinating the Navy's research program and will advise the Chief of Naval Research and the Chief of Naval Operations on research matters. It is hard to believe that such a committee would permit the Naval service to dominate and hamper scientists and to so control science that there might be a future danger as to trends in these fields.

There has been so much comment recently to the effect that the military arms are taking over science that I hope I will be forgiven for dwelling on the subject. As I said earlier, in the basic work sponsored by the Office of Naval Research, the scientists are free to work as they choose in their own laboratories.

It seems to me that who provides the funds for research work is immaterial. The important point is that the work is being done. Fundamentals are fundamentals. No one can guide those discoveries or the trends which they may take.

The Navy is in favor of the proposed National Science Foundation and we feel that if and when such an agency is set up it will certainly take over some of the programs now being sponsored by us. In addition, a National Science Foundation would make available a central agency for the assembling, indexing, and storing of research information which would be available not only to the military service but to all. Any knowledge we may have gained in the meantime will of course find its way into this national research storehouse. I strongly suspect the Foundation will pattern its policies and organization along the same channels that we have started, but let's not forget that the Navy will always have to participate in science because only in participating can it understand science and utilize the fruits that it provides. Even with a National Science Foundation the Navy still has the responsibility of preparing the Navy for national security.

Many people do not realize that during the war years, we were withdrawing from our bank account of fundamental scientific knowledge

without making any deposits. And the bank of knowledge is one from which it is impossible to overdraw. That bank account must be brought to the point where it is the greatest depository of scientific knowledge in the world, and so maintained. The Office of Naval Research, through its partnership with scientists, is helping to restore our bank account and we hope not only to continue to help but to accelerate our rate of deposits. We believe that each new piece of knowledge put in the bank will stimulate more new thinking, which in turn, will stimulate more, and so on. In other words, this bank account will draw a high rate of compound interest.

It is my hope that I have given you an idea of the scope of the Navy's basic research program, the largest Federally-financed research program ever undertaken in its history. More important, I hope I have shown you how we are operating, and why. Who we want as partners, and why it was vitally necessary for us to get this program underway at the time we embarked on it, more than a year ago.

We are, I believe, all agreed that the seeking of new knowledge in this country must not slacken. Therefore, the details for whom the work is being done are not important as long as all of us interested in scientific research understand the problems involved, and understand each others' aims and ideas. Such meetings as this provide invaluable opportunities for such understanding.

ANTHROPOLOGY

Chairman: W. B. ADAMS, Bloomington

Dr. Erminie W. Voegelin, Indiana University, was elected chairman of the section for 1947.

ABSTRACTS

Some possible eastern woodland names for the Yuchi. E. W. and C. F. VOEGELIN, Indiana University.—A preliminary investigation of possible designations for the Yuchi tribe based on source and field material.

Notes on the craniology of the Indians of the Northwest Pacific Coast. GEORGE K. NEUMANN, Indiana University.—A re-examination of several series of crania of Northwest Coast Indians revealed a number of interesting new relationships. Thus, a small series of putative Athapascan crania from the Yukon Valley are practically identical with skulls of the Margid variety found in early horizons of the southeastern states, Basket-Maker II crania, and those of Indians of southern California and northwestern Mexico. A second element, already noted by Dixon as an early substratum, is found in mixture among the Haida, the coast Salish, and Kwakiutl, is dolichocephalic and closely related to the people of the Frazer River shell heaps, the Kootenay, and Eastern Woodland Sylvids. The third element, representing the most recent intrusion, both along the coast and from the interior, consists mainly of people of the Pacific variety. It contributed to most present tribal groups and became highly mixed with earlier elements along the coast. Relatively unmixed remnants persisted as inland Athapascans, a number of Salish-speaking tribes, and the Apache.

Some rare or new middle Mississippi traits. GLENN A. BLACK, Indiana Historical Society.—This paper is intended to call attention to some culture traits which have either been rarely reported or not previously reported and at the same time make a plea that a search for them be made. The traits are; cut deer or wapiti astragali which have only rarely been reported. Scored stone tablets reported from only one site previous to the Angel Site exploration. Fossil bones reported from one previous exploration. Painted house wall or "daub" which has never before been reported from an archaeological site. Negative painted sherds lacking and overlay or "slip" of red pigment. The above items have all been found at the Angel Site and form a part of the component material culture complex. They should occur at other Middle Mississippi sites.

Deformed ears of corn as objects of worship in pre-Columbian America. PAUL WEATHERWAX, Indiana University.—There are numer-

ous artifacts and a few references in the literature of the early Spanish Colonial period which indicate that branched or otherwise deformed ears of corn had a religious significance in various parts of America before Columbus came. Some varieties now grown in out-of-the-way places have a large percentage of deformed ears.

An analysis of surface material from the Mann site. WM. R. ADAMS, Indiana Historical Bureau.—This paper presents an analysis of material collected on the surface of a possibly stratified village site in southwestern Indiana. A brief description of the site is followed by statistical groupings of the pottery sherds in regard to both tempering agent and surface treatment, with an attempt to point out possible relationships for the complicated stamped ware found on this site. An undetailed tabulation of the non-ceramic materials is included.

In Retrospect—The Early Archaeologist and His Contribution

Arthur B. Carr, Indianapolis

With knowledge of the rapid progress which present-day archaeological research is making toward a solution of vital prehistory problems, one naturally harks back to early indications of interest in the collection and study of prehistoric artifacts, the enduring documentary evidence of the past existence of primitive peoples.

As among friends, may I say that, acting upon the suggestion that I participate actively in this program, I have prepared what seems a far cry in nature from the usual strictly scientific papers of members of this section, seeking to present that early phase and period, potentially important to later study, and perhaps refresh your memories relative to the awakening of your own interest in anthropology, perhaps through a lucky find during a hiking trip, the specimen becoming the nucleus of a worthy collection, or at least an inspiration for the pursuit of a wholesome and fascinating study.

With such a background, one may imagine the enthusiasm of those who, during and immediately following the pioneer period, might gather with little effort, large quantities of implements of human manufacture, the use of which could only be conjectured, since perhaps little used if at all by the historic Indians living within the region until 1838, sixteen years after the Pigeon Roost massacre in Scott County.

To those early hobbyists, the sight of man-made mounds and fortifications was doubtless awe-inspiring and wonder-provoking, but conjecture satisfied for a time the latent desire for definite knowledge. Perhaps the obvious purpose and usefulness of their valued pieces was their foremost interest. Content with the collection of surface finds, they were of the theoretical school af archaeology, leaving action for those of that other, the later practical school, whose followers elected to dig, preserve, study, and compare discoveries in various sections, with a definite knowledge of ancient man the objective of perhaps their lifelong effort, their work being covered by the term anthropology, the study of man.

The early amateur scientist doubtless envisioned the extensive use of soft substances, as wood and other perishable material by the makers of his stone artifacts, but sources of enduring material, classification, methods of manufacturing, chronology and culture were of little concern, and terms such as "pattern", "phase", and "aspect", were archaelogically speaking, foreign to their vocabularies. May we not acknowledge that even today, lists of traits of culture patterns need perhaps be modified, through inevitable involvements and influences, which tend to alter decisions?

Many notes and details of early discoveries, resulting in the published records in the early Geological Reports of Indiana, on archaeological finds in our state, describing with accuracy the surface objects, the location of sites and contour of fortifications et cetera, which even then were obscure and almost unrecognizable, were largely the contributions of those zealous amateur collector scientists of yesteryears, whose research methods were primitive, though effective, and helpful to those of experience who came after them. We concede the vastly superior composition and scientific accuracy of the present day publications, the splendid Prehistory Research Series, and the numerous other reports.

Inadvertantly, the early collector engaged in a little "digging", perhaps to satify curiosity, or work off surplus energy, but almost invariably with disappointing results. Surface finds were sufficient to meet the desire of the most ardent collector, so the few disturbed monuments seldom brought serious discouragement to later, authorized excavators. In this, I may not have your complete approval, but why begrudge those early enthusiasts their occasional indulgence in a little skeletal uncovering? After all, artifacts found, invariably came down to posterity.

I should mention the willing cooperation of early collectors in various communities who welcomed in their midst many eminent archaeologists who came from time to time; and contributed in a large way to the success of the efforts of the visiting scientists, who sought local data, and engaged in exploration and excavation. Present day research is benefitted by such helpful measures.

It appears that the practice of exchange of relics between early collectors of a community was prevalent, but with little infiltration of material from outside, or remote sources, so that most such collections might be considered as localized, a factual asset in later scientific research.

I ask your indulgence for projecting into the picture something of a personal nature, through introducing James L. Carr, my father, as one of those early archaeologists of amateur status, who had opportunity to explore over large areas of virgin soil but recently "cleared" and broken by the plough. As a young man he developed interest and zeal in the study of the mysterious forms of Indian origin so numerous in Clark County, his native section of the state, that adjacent to the Falls of the Ohio, and rich in antiquities. This region in recent years has been the scene of much carefully planned and executed excavation and research, chiefly by E. Y. Guernsey, whose youthful beginnings in anthropology were engendered through contact with father and his hobby. (I may say that E. Y.'s father and my father's mother were brother and sister.) I mention also that another, a recognized authority in his line, our own Glenn A. Black, graciously ascribes his initial interest in this field, to have been the same source, though later, in Indianapolis.

Through the years Carr's village store was the setting for many hundreds of transactions, whereby pocketsful of flints, quantities of grinders, diggers, axe-heads, hammers and other queer shaped Indian stones, (to use familiar terms of the period), brought in principally by

boys of the farm, whose watchful eyes frequently detected the unusual forms as they tilled the soil, were gladly relinquished, the medium of trade usually being handsful of peanuts and candy, possibly a Barlow knife or a pair of gallouses, since the common relics had little intrinsic value. Somewhat rare or more sought after types however, were always acquired at "fair" and even "fancy" prices. At times the seller would drive a hard bargain with success. So numerous that they were picked up with comparative ease, the relics served as an incentive for frequent trips to town. It is related that it was sometimes difficult to restrain a small trader from giving a pyrotechnic demonstration to show the high efficiency of his choice arrow or spear heads through "making the sparks fly" as he said. There is abundant evidence of such mutilation in every collection.

With not too much local competition, father's collection grew apace, and at its peak numbered in the thousands. To encourage the collecting spirit particularly among his youthful townsmen, he through the years made gifts of specimens and small groups of objects to those interested. Pictorial evidence of its meagre beginning is a small tintype of his early collection, but of the pieces shown thereon, three are illustrated in Mr. Eli Lilly's "Antiquities of Indiana", published nearly eighty years later, in 1943, as are others, father's collection with some of my own material having been incorporated into the valuable Indiana Historical Society collection. May we not conclude that through preserving the vast numbers of choice Indiana artifacts which finally came to be a part of that famous aggregation of material, the collectors of our state extended a worthy service?

Contemporary with father's activities, were those of his friend Prof. W. W. Borden and others, some in adjoining counties, while across the Ohio, in Kentucky, General Bennet H. Young and others were amassing large accumulations of valuable material, and giving intensive study to finds and sites in that state.

I find in father's files interesting correspondence with eminent collectors of those early years, also of later date his certificate of membership in the International Society of Archaeologists, with Bulletins of that organization published in 1909 and succeeding years, which had a circulation of around six thousand copies. Laudable aims of the Society were:

To lessen as much as possible the reckless opening of Indian graves and mounds;

To curb the mercenary spirit so manifest in some individuals;

To unite the collectors and students for mutual aid and protection;

To expose frauds and makers of fake relics.

From this source I quote a statement from an Indiana collector and dealer who had been expelled because of fradulent practices. Quote—"I do not care where a thing comes from, or what it is, if I buy it as an Indian relic, I will sell it as an Indiana relic". Fortunately, in the early years of collecting, there was little incentive for fraud, and seldom was it practiced. With an almost uncanny ability to detect

fake artifacts, authorities of today could scarcely be misled into the acceptance of pieces not genuine, except perhaps for use as type replicas.

It has been said that the commonest artifact of prehistoric workmanship loses nine-tenths of its study value after having passed through the hands of a dealer, since it has probably completely lost its identity as to location, though its monetary value may have increased through commercial manipulation, regulating supply and demand. Even in fair dealing, the "Almighty Dollar" the predominant religion of the many, has often been a deterrant in the pursuit of archaeology.

Fortunately, few of the early collectors could rightfully be classed as dealers, and it is our observation and contention that the innumerable hobbyists, with their groups of implements of prehistoric life of the region, gathered, and preserved intact, have made a distinct contribution and proven a great boon to the study of physical anthropology, and the remarkable present day unraveling of the knotty problems concerning ancient peoples of Midwest America.

Thomas Dean and the Delaware Towns

PAUL WEER, Indiana Historical Society

The journey of Thomas Dean (1) from Deansboro, New York, to the Delaware Towns on White river in central Indiana during the summer of 1817 definitely indicates that Chief Anderson was at that time the principal chief of the Delawares in the White river country, and that his seat of residence at Anderson's Town (now Anderson, Indiana) was the seat of government and principal Delaware Indian town. From other sources we had come to the conclusion that the two most eastern towns on White river had been abandoned prior to the year of 1820. Dean's journal strengthens that conclusion.

By letter dated Paris, N. Y., May 12, 1817, Asabel Curtiss Doolittle and Joseph Stebbins, Superintendents of Indian Affairs, wrote to

"The Honourable Governor Of Indiana Territory and to the Agents of the several Tribes of Indians in said Territory,

Gentlemen:

Having been informed that a certain tribe of Indians residing near White River in your Territory have proposed to grant to the New Stockbridge and Brothertown Indians, who now reside in the Counties of Oneida and Madison in New York State, a certain tract of land upon certain conditions,

We therefore, as Superintendents of the said New Stockbridge and Brotherton Indians, beg leave to represent that they are now about to set out on a journey to that country to accomplish that business, and that they have agreed with Mr. Thomas Dean, an inhabitant of the County of Oneida, to accompany them and to be their agent to negotiate with said Indians, or their agents in your Territory, and as we are personally acquainted with Mr. Dean, we do not hesitate in recommending him as a suitable person for that purpose, and as a gentleman in whom you may place the greatest confidence.

Any assistance which you can afford him in transacting his business will be considered a singular favour and gratefully acknowledged by your humble servants."

Thomas Dean was born in Westchester County, near New York City, in 1783, of sturdy Quaker stock. In 1798 the family moved to Oneida County, N. Y., and founded the town of Deansboro. From his father, formerly a part time misisonary to the Indians from the Society of Friends in New York City, Thomas naturally acquired his sense of obligation to the Indians. In addition to his very active life as a farmer, postmaster, owner and operator of the Friends Cotton and Woolen Manufactory, and as a member of numerous boards of trustees, including Hamilton College, he devoted much time and thought to the welfare of his Indian neighbors, the Oneidas, the Stockbridge, and the Brothertowns. For these groups he eventually acted as attorney and agent. The Brothertown group consisted of remnants from several New England and New York Algonquian tribes,—Mohegan, Mahican, Wappinger,

Pequot, Montauk, Narraganset, and others. A tract of land had been purchased for the Brothertowns in 1774 in Oneida and Madison Counties from the resident Iroquoian Oneida tribe, but due to the anti-American attitude of the Iroquoian Mohawks during the Revolutionary War, possession of these lands was not available until 1788. Ten years later when the Deans settled in Oneida County, the Indians were beginning to feel cramped by the white settlers; and in 1809 the Brothertowns sent word to the Delawares and Miamis in Indiana Territory inquiring their attitude concerning the purchase of a new home on White river. The tribes reached a mutually satisfactory agreement, but before the Brothertowns could migrate subsequent treaties with the whites removed the tract from Indian control, and cost the tribe all it had expended on the deal.

The negatiations of 1817 culminated in an all water journey from central New York to the Delaware Towns in central Indiana. The Delawares, around their own council fire in Anderson Town, refused to negotiate; and it was just as well, for at the treaty of St. Mary's the following year they lost all of the White river lands to the sovereign State of Indiana. But Dean was not through. In 1824 he acquired by treaty and purchase from the Winnebago and Menominee a tract of 240 square miles on the Fox river in Wisconsin for his Brothertowns, which land, due to title disputes was exchanged in 1828 for 23,000 acres on the east shore of Lake Winnebago. The Brothertowns established themselves in this new home in 1833, and along with them came their old neighbors the Oneida and Stockbridge. The three tribes shortly thereafter abandoned their Indian tribal life and became citizens of the State of Wisconsin.

Dean's trip to The Delaware Towns was made overland by foot and horseback from Fort Harrison, beginning August 1, 1817. Some days prior thereto, a boat christened the Brothertown Enterprise docked at Vincennes, 50 days out of Deansboro, N. Y. The boat had been made by Dean himself. The latter part of July 1817, there appeared in the Vincennes Sentinel an article written by Dr. Shuler of that city, summarizing the journey of the good boat Brothertown Enterprise. No copy of this paper for that issue is known to be in existence, but fortunately the article was reprinted in the Western Sun, at Vincennes, July 11, 1826. Quoting Dr. Shuler:

"The extensive inland navigation of the western country is strikingly exemplified by the late arrival at this port (Vincennes, Sunday, July 20, 1817) of the elegant schooner built boat, "Brotherton Enterprise", of six tons burthen, from Deansboro, N. Y. in fifty days. This boat left the Mohawk River (Oneida Creek), on the first of June last, under the command of Thomas Dean, and is navigated by four Indian men, accompanied by two Indian women and an Indian boy, all possessing habits, manners and education idicative of the most complete and refined civilization. [The seven Indians were the chiefs and leading men of the Brothertown tribe: Paul Dick, Jacob Dick, Thomas Isaacs, Charles Isaacs, Rudolphus Fowler, and two cooks, wives of two of the chiefs, Sarah Dick and Betsy Isaacs.]

The object of Capt. Dean and company is to obtain from the Wabash Indians the cession of a tract of land for the Brotherton Indians in consequence of an invitation given by the former. They intend to ascend the Wabash to its source, and by a short portage, to pass over into the Miami of the lake, by which

they calculate to return. The whole route will, they calculate, be performed by the first of September, making (in the short space of three months) a journey of between two and three thousand miles. . . .

From Deansboro they passed through Wood Creek into Oneida Lake, from which they descended the Oswego River into Lake Ontario—Coasting the south side of that lake to Niagara Falls, they carried their boat on wheels from Queenston to Chippawa (a portage of eleven or twelve miles), back to Niagara River which they ascended into Lake Erie, along that lake to the mouth of Cataragus Creek, and up it to a portage of eight and a half miles, over which they passed into Chautauque Lake, and down the Conewongo into the Alleghany. The Alleghany, Ohio and Wabash present a smooth and uninterrupted navigation to the head of the Wabash, a portage of nine miles connects the Wabash with the Miami of the lake, over which Capt. Dean intends to transport his boat, and descend the Miami into Lake Erie. He will coast that lake to Buffalo, N. Y."

The Wabash-Miami portage proved to be too much. After an unsuccessful attempt to get it through to Fort Wayne, the boat was brought back to Fort Harrison, and sold September 4. Dean actually pushed the boat up the Wabash to somewhere near the mouth of the Mississinewa. They were never sure whether or not they saw the Mississinewa. After selling the Brothertown Enterprise the party traveled by foot and horseback to Fort Wayne where they arrived September 18. Dean could not buy a boat there, so went out into the forest, cut down a tree and in two days he and the Brothertowns fashioned a pirogue large enough to carry them all, their baggage and two extra passengers. Leaving Fort Wayne September 24 on the Miami river, during the morning of September 28 they reached Fort Meigs where they met Governor Cass and General McArthur holding a treaty with the Delawares, Shawnee, Wyandotts, Pottawottomis and "some other tribes". At the conclusion of the treaty Dean and his party obtained passage to Detroit on the boat Fire Fly; and from Detroit reached Buffalo on the schooner General Wayne.

The journey to the White River country and return was started August 1, 1817, from Fort Harrison. The boat Brothertown Enterprise was left at the fort under care of Major Chunn. Quoting from the Journal:

"August-1. They told us we could go through in three days if we had horses, it being one hundred miles, so we concluded to take three days provisions and get horses if we could, but it happened that there was not more than one pound of meat put up. We took three guns and an ax, started about 10 AM, and our guide went on with us. The weather was very warm, and we had to go through the prairie about seventy-two miles, which was very hot and uncomfortable. We could get no water to drink until we went about thirteen miles, where there was good water and a family lived. Here they gave us some milk to drink. After we had refreshed ourselves we left two guns and proceeded."

On August 4 the last (third) gun and the ax were left at a Wea village. The journal adds: "but we took a hatchet." This Wea village was probably on Sugar Creek, approximately six miles north of the present Thorntown, in Boone County. (2)

August 6, the sixth day out from Fort Harrison, the party crossed White river, and, quoting from the Journal:

". . . went to the house of William Conner, a French trader, whom I found had gone to Philadelphia. His partner, William Marshall had gone to Muncie,

a town 25 miles up the river. The women could not speak English, but we found they had gone down the river. We went down across the prairie about a mile, crossed the river, and went about four miles to a settlement of the Delaware Indians, carried our packs, and then met them at the lower village. (3) They gave us some bread and milk to eat. We invited them to go to Fort Harrison to the council, but they did not agree to go. We returned, crossed the river, and went to Conner's to get a horse to the upper town (4) but got none. Joe, Paul, and Rudolphus started on foot about half past 5 PM., the rest concluded to stay, and soon after William Marshall came home. He said we could not get any of the Delawares to go to Fort Harrison, they were all going to Fort Meigs to a treaty there the fifteenth of September, so we concluded to go up in the morning. Marshall would furnish me with a horse to ride. It is about forty or forty five miles from the Weas to the White river, making about 140 miles from Fort Harrison."

The Journal for August 7:

"We took breakfast at Conner's, hired a horse, and proceeded on up to the other town. We reached the settlement about 10 o'clock p.m. [a.m.?], obtained some bread and buttermilk, then went on toward the principal Indian village and met Paul Dick with horse going for us. He said the council must be held at the village where Anderson lived. We went up and met several at his house, was appointed a council on the morrow. We were furnished with supper, which consisted of bread and herb tea. . . . We put up at the house of the principal chief. It was as good as any in the village, and he, a plain, majestic looking man, sixty or sixty-five years old. Paul and Fowler were directed to another house to lodge, and the rest of us lodged at the chief's. I had the most comfortable place. It was some boards or staves put on benches, and bullrushes laid on them, and a small pillow, though it was wet in the shower."

The council took place next morning, August 8. The journal for that day is as follows:

"We got together in the morning and were served with some boiled corn and venison for breakfast. After breakfast the people began to come in, and we were soon served with another dish of squashes, made sweet with sugar, and some bread, which we partook of. After the chiefs and councilmen and principal men of the nation came in they informed us that they were ready to hear what we had to say. I spoke to them, . . . and the reply was made by Anderson (Keklawhenund) the principal chief."

The Delawares refused to join the council at Fort Harrison, and the negotiations came to an abrupt end. Continuing the journal for that day:

"There were twenty or thirty Indians who attended the council, which lasted about four hours. We went to look for the horse that I rode, but did not see it. We mentioned that we wanted some provisions to take on our [return] journey, and we were informed that they would be brought in the morning, so we put up for the night, myself, T. Isaac, T. Dick at the chief's, P. Dick and R. Fowler at another house."

Journal for August 9:

"Our provisions soon came in. They were hoecakes and Indian bread. We received two or three pairs of moccasins. Thomas Isaac found the horse and after breakfast we took our leave, went down to the Nanticoke village (Nancy-town), obtained some buttermilk, Indian wampum, and butter from a woman by the name of Nancy, and then started for William Conner's. In the afternoon it rained very hard and we were very wet. We came down to Conner's about 5 o'clock and prepared to start in the morning for Fort Harrison."

May, 1801, the Moravian Missionaries came into the Delaware country on White river to set up their mission. Coming in from the southeast, up the White Water river, and across country from where the city of Brookville now stands, they entered first the eastern most of the Delaware towns: Wapicomekoke, or Old Town, residence of the principal chief, Chief Buckongahelas. Here, according to the missionaries, lived about forty Indian families. This town, one of the missionaries, Abraham Luckenbach, said, was also known by the name White Grave. Chief Tetepachsit lived in Monsy Town about four miles down the river. His town consisted of about eight families, and was on the right (north) bank of the river where the city of Muncie now stands. Chief Anderson lived in Anderson's Town, where the city of Anderson now stands. His Town was made up of about 15 or 16 Delaware families. (5)

Buckongahelas died in 1805, and rumor has it that Old Town was abandoned shortly thereafter and its inhabitants moved to Munsey Town or drifted off into new territories. The following year Tetepachsit was murdered by his own people through the influence of the Shawnee Prophet, Tecumseh's brother. From 1810 to 1820, and indeed until the Delawares left the State of Indiana, Chief Anderson was recognized as the principal Delaware chief in the Delaware Towns on White river. (6) The fate of the two easternmost Delaware towns was a reasonable expectancy due to the pressure of the incoming whites east and southeast of them. As a matter of record, when the white settlers began pouring into Delaware Cuonty in the early 1820's Old Town was even then only a tradition, and Munsey Town an old cemetery in whose environs lived three Indians—an old man, a woman and a boy. (7)

In the year 1820, John Tipton wrote in respect to the Delaware towns as follows:

"The Delaware Towns are scattered along the west fork of White R from Town 17 N of R 3 E up to Town 20 N of R 9 E a distance of 40 miles, Called Brewits, Conners, Bucks, Straw, Anderson Town and many others of less note." (8)

Tipton was very exact in such matters. Township 17 North, Range 3 East exactly located the lower Delaware Town in northern Marion County. This he called Brewits. (9) Both Munsey Town and Old Town are east of Tipton's eastern limits for the above towns; nor are either of them in his list.

In the year 1818 the United States Government gave the site of Munsey Town to a half blood Miami woman. Quoting from the Miami section of the Treaty of St. Mary's, signed October 6, 1818:

"To Rebecca Hackley, a half-blooded Miami, one section of land, to be located at the Munsey town, on White river, so that it shall extend on both sides to include 320 acres of the prairie, in the bend of White river where the bend assumes the shape of a horseshoe." (10)

The total grant included 672 acres, because the grantee refused to accept river acreage in the total of 640 acres, that is, one square mile. Rebecca Hackley was the wife of Captain William Hackley, U. S. Army, stationed at Fort Wayne, and the daughter of Captain Wells, and the grand daughter of Chief Little Turtle.

Delaware County was surveyed by David Hillis in 1822. The Rebecca Hackley grant is shown on his drawings, and "Munsee T." is marked therein on the right (north) bank of the river where the city of Muncie now stands. (11) The Hackley Grant was purchased in 1825 by Goldsmith C. Gilbert, and two years later on part of this land the white settlers' village Muncietown was organized. (12) Buckongahelas' town, Wapicomekoke, or Old Town is not shown on the Hillis survey. His papers in Indianapolis (13) unfortunately show only the river where it crosses section lines, and not its complete meanders through the County. In the hope that records, in Washington might show these latter, we wrote to the U. S. National Archives Division of the Department of the Interior, August 29, 1946, for copies of the original survey's plats for Delaware County, and copies of the field notes covering them. October 11, 1946, James F. Homer, chief of the Division, wrote to Miss Margaret Pierson, chief of the Archives Division, Indiana State Library, in part as follows: "Our office can furnish you with photostat copies of the plats of T.20 N, Rs 9, 10 and 11 E . . . . showing the White River. . . . . We have no field notes for the meanders of the river." The question is: Will or will not these photostats show the location of Old Town?*

The fabulous labor of Dean and his Brothertown Indians came to its climax in Chief Anderson's Town. The preparation and toil totaling the sum of their labors, the quality of the expedition's leadership, make self evident there was nothing to command their interest in the Delaware country to the east of Anderson's Town.

Literature Cited

1. The quotations and other material on Thomas Dean and his journey to the Delaware towns, from Dean, John Candee, 1918. Journal of Thomas Dean, a Voyage to Indiana in 1817. Ind. Hist. Soc., Publ. **6**:271-345.

2. Id., p. 314.

3. This was the lower Delaware town in T17N, R4E, visited by John Tipton in 1820. 1942. The John Tipton Papers. Ind. Hist. Bur., **1**:197-200.

4. The upper town was north of Conner's. For its probable location, and a discussion of the locations of all the Delaware towns on White river, see Thompson, Charles, N. 1937. Sons of the Wilderness, John and William Conner. Ind. Hist. Soc., pp. 41-43, and notes.

5. Stoker, H. E. Translator. 1917. The Autobiography of Abraham Luckenbach. Trans. Moravian Hist. Soc., **10**. Bethlehem, pp. 375-379.

6. Bur. Amer. Ethnol. Bul., **30**:57.

7. Helm, T. B. ed. 1881. History of Delaware County, Indiana. Kingman Bros., Chicago., pp. 32, 36, 38, 46.

Ellis, John S. 1898. History of Delaware County. Neely Printing Co., Muncie, p. 118.

Cecil, Samuel. 1905. Ind. Quar. Mag. Hist., **1**:178-179.

8. John Tipton Papers, v. 1, p. 215. This appears in the Journal of the Board of Commissioners appointed to locate a site for the permanent seat of Government for the State of Indiana: JOURNAL May 22—June 7, 1820.

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* Since the above was written, we have been informed that the field notes for Delaware County in Washington are identical with those in the Indiana State Library.

9. See "Indian Settlement on White River"—Western Censor and Emigrants Guide, a weekly newspaper printed and published by H. Gregg and D. Maguire, on Washington Street, near the centre of town—V. 1, No. 13, for Wednesday, June 11, 1823, Indianapolis.

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11. Records of Surveys (unbound): Brookville and Fort Wayne Districts, in Township Plats, No. 31. Archives Division, Ind. State Libr.

12. Kemper, G. W. H. 1908. History of Delaware County, Indiana. Lewis Publ. Co., Chicago. pp. 103-105.

Haimbaugh, Frank D. ed. 1924. History of Delaware County, Indiana. 2V. Hist. Publ. Co., Indpls. 1:433-436.

13. Archives, Ind. State Libr., Margaret Pierson, chief.

BACTERIOLOGY

Chairman: F. A. Miller, Eli Lilly & Co.

Dr. Stanley E. Hartsell, Purdue University, was elected chairman of the section for 1947.

ABSTRACTS

Mycology for the Bacteriologist. C. L. Porter, Purdue University.—The Bacteriologist has regarded the fungi in the past as some of the less promising step children of his family of microorganisms. The many new industrial and medical products, results of fungus fermentations, have given the fungi perferred standing with the Bacteriologist. The mycological training of most Bacteriologists is inadequate to cope with fungus problems in the most efficient manner. The author outlines areas of information which should be considered as the minimum essentials of Mycological training.

Biosynthesis of Penicillins. Otto K. Behrens, Lilly Research Laboratories.—Early in the course of the program on the determination of structure and synthesis of penicillin it became apparent that the synthesis was by no means assured. Interest in biological production was therefore maintained. It seemed probable that one of the factors limiting the biological production was the mold's metabolic inability to supply one or more of the fragments which appear in the penicillin molecules. This has been found to be the case. Additions to the medium of certain precursor compounds which provide the acyl portion of the molecule either directly or after metabolic transformation, cause a marked stimulation in yield. This work has also led to the discovery that use can be made of precursors to induce the formation of new penicillins containing different acyl groups. In many cases these new penicillins are formed in good yield (60 to 100 percent of the total penicillin formed). A number of the new penicillins have been crystallized and characterized.

On Friday afternoon the Bacteriology Section met with the Indiana Section of the American Society of Bacteriologists where the following program was presented:

1. Interference between the Cambridge Swine Strain of Influenza and the PR8 Human Influenza Virus. M. Michael Sigel, 1st Lt., SnC. Fort Benjamin Harrison.

2. The Experimental Evidence Supporting Canine Anti-rabies Vaccination. Samuel R. Damon, Bureau of Laboratories, Indiana State Board of Health, Indianapolis.

3. A Method of Inoculating Embryonated Eggs for the Propagation of *Rickettsia Prowazeki.* H. A. Dettwiler and F. A. Darling, Lilly Research Laboratories, Indianapolis.

4. Estimation of Biological endpoints by semi-logarithmic graph paper. Frank Streightoff, Lilly Research Laboratories, Indianapolis.

5. On the relation between penicillin resistance and production of penicillin inactivators in staphylococcus. S. E. Luria and Rachel M. Arbogast, Indiana University and Indiana and Carnegie Institution, Cold Spring Harbor, N. Y.

6. Improving Streptomycin yields by strain selection and inoculum development. Alfred R. Stanley, Research Department, Commercial Solvents Corp., Terre Haute.

7. Nutrition of *Streptomyces grisens* in relation to Streptomycin titer. Ralph E. Bennett, Research Department, Commercial Solvents Corp., Terre Haute.

8. Isolation of a pure culture of a cellulose digesting bacterium. L. Y. Quinn, Bacteriology Department, Purdue University.

9. Use of kittens for demonstration of enterotoxin production by strains of *clostridium* prefringenf implicated in human food poisoning. Rafael Marinelarena and L. S. McClung, Bacteriological Laboratories, Indiana University.

10. Flagellar and Somatic agglutination of clostridium bifermentians and clostridium sordelli. Helen Michael and L. S. McClung, Bacteriological Laboratories, Indiana University.

11. Lecithinase production by clostridium hemolyticum. L. S. McClung and Ruth Toabe, Bacteriological Laboratories, Indiana University.

BOTANY

Chairman: J. E. POTZGER, Butler University

Dr. Noe Higinbotham, University of Notre Dame, was elected chairman of the section for 1947.

ABSTRACTS

A pollen study in the tension zone in the Saginaw-Muskegon area of lower Michigan. J. E. POTZGER, Butler University.—Aim of the study was to discover the history of the forests along the tension zone of southern limits of the lake forest by means of pollen analyses of sediments of 12 bogs located on as well as a short distance to the north and south of this line. The pollen records show a very uniform early history in a belt approximately 25 miles to the north and the south of the tension line. Successional changes are: *Picea glauca* to *Pinus banksiana*, to a combination of *P. banksiana* and the taller pines *(P. strobus, P. risinosa)*. In areas where the dominance of Pinus was replaced, or greatly modified by invasion of deciduous genera, numerous combinations of key genera appeared, viz. pine-oak; pine, oak and mixed hardwoods; pine, oak, elm, beech; pine, hemlock, beech. The southern limits of important representation of hemlock is in the zone 25 miles north of highway 46 in the central locations but swings southward at least 15 miles along Lake Michigan. It never reached more than 3 per cent of the total pollen count in bogs south of this line. An approximate successive decrease of 10 per cent in maximum oak pollen every 10 to 15 miles northward between Holland and Farwell, Michigan, the sudden decline of hemlock near the Saginaw-Muskegon line, successive reduction of importance of pine southward within the 50-mile wide belt marks the area as a very critical tension zone. This condition has persisted for a relatively long period of time. Moderating climate during the more recent past is suggested by marked increase in oak pollen representation in four bogs along the tension line.

Some observations on white pine *(Pinus strobus L.)* on Clark state forest. DANIEL DEN UYL, Purdue University.—White pine *(Pinus strobus)* although native to Indiana was not found in the forests of Clark County, Indiana. On the Clark County State Forest tree planting work started about 1904 but not until 1912 was white pine used in experimental plantings. Following these early experiments a number of white pine plantations have been established. Studies of these plantations in 1945 show that 25 year old stands support 400 trees per acre ranging from 5 to 12 inches in diameter and from 30 to 60 feet in

height. Growth of the stands is approximately one cord per acre per year.

Sporulation in the genus Trichoderma. O. G. WEGRICH, Purdue University.—The method by which the genus Trichoderma sporulates has not been described to the satisfaction of the author. It is said by other workers that spores are borne sessile, in a head and not catenate. Observations made by the author indicate that the spores are borne in a catenate manner and then adhere forming a "head-like" mass. Sporulation is described in detail with illustrations.

The bottom configuration of the Cabin Creek raised bog and the history of the forests of the region. RAY C. FRIESNER and J. E. POTZGER, Butler University.—The Cabin Creek bog differs from all other raised bogs studied to date in the complex topographic configuration over which it has spread. Borings made at 50-foot intervals on 8 radii, all of which pass through the central, deepest portion, show that the base upon which deposition was made comprised a narrow, deep central valley with steep sandy slopes on either side of which were other shallower ravines and sand ridges. The base upon which deposition began was thus considerably dissected. Correlation of character of deposits and pollen profiles shows that the deepest central depression filled in rapidly through water wash from the adjacent steep slopes and through precipitation of marl; while the ridges and more elevated areas accumulated "land-deposited" material. These depositions apparently took place simultaneously, beginning soon after the removal of the ice. The "land-deposited" material comprised wood peat, sedge peat, and sedge-wood peat. A higher percentage of the total profiles is occupied by spruce dominance than in any other bog studied. From this it is concluded that the deposition in the valleys and ravines must have been quite rapid since approximately the same time interval is involved in deposition of the lower 28 feet in the deepest depression and the lower 7 feet in the boring whose bottom was on the top of a sand ridge. Conversely, the upper levels of deposition must have occurred very slowly. Only 4 feet of deposit occurred in the valley, and 6 feet on the ridge since the close of the period of spruce dominance. The surface of the deposit on the ridge top is 10 feet above the level of the bog margin while that of the deposit in the valley is only 10 inches above the level of the margin. The close of the spruce is followed rather abruptly by a mixed mesophytic forest in which oak is more abundant than any other single genus. (To be published in Butler Univ. Bot. Stud. 8 (2). 1946.)

Pollen profile from a Texas bog. J. E. POTZGER, Butler University and B. C. THARP, University of Texas.—Presented in the paper is a pollen study from the 22-foot deep Patschke Bog in Lee County, Texas. Points of greatest significance are the presence of pollens of Abies, *Picea glauca*, *P. mariana*, and Castanea. The present range of Castanea is at least 100 miles eastward of the station. Grasses and Alnus play important roles in vegetational fluctuations. Variation in focal points of pollen size-classes of grasses strongly suggest that the

association of grasses was not uniformly the same for the whole period involved. Climatic changes suggested by the vegetation are: Cool-moist (boreal conifers and Pinus); dry-warm (Quercus and grasses); warm-moist (Alunus and Castanea); dry-warm (Quercus, Carya, grasses).

A five-year dendrometer record in two trees of Pinus strobus. RAY C. FRIESNER, Butler University.—Weekly dendrometer readings over a five-year period in Maine shows that temperature is the most important single factor involved in determining the time of initiation of radial growth in the spring. This varied from April 15 to May 26 and ranged from a few days before to as many days after the mean daily air temperature was continuously above 50° F. Awakening of radial growth closely followed the time of beginning of swelling of terminal buds. Rate and amount of weekly radial changes was irregular with no definite cycles apparent. Shrinkages due to dehydrations were correlated with periods of deficient soil moisture, but at no time were they of more than two weeks duration. During the dormant season, shrinkages and recoveries were numerous and of varying extent and duration. The average annual radial enlargement was 6.97 mm in tree A and 6.36 mm in tree B. Correlation with stumps of cut trees showed that 70 years was the average age of trees measuring around 30 inches in diameter. Amounts of radial enlargement show a fair degree of correlation with percentages of average annual rainfall, the correlation being closest when rainfall change is from well below average to average or above average. Duration of radial enlargement varied, in the two trees, and over the five-year period, from 17 to 28 weeks. Cessation of radial enlargement varied in time from the week ending September 18 to that ending November 1. There was no correlation between duration and amount of radial enlargement. (To be published in Butler University Botanical Studies 8 (1). 1946.)

Studies in the Stromatic Sphaeriales of Indiana[1]

EMORY G. SIMMONS, DePauw University

This paper is the first in a series of taxonomic reports covering the stromatic members of the order Sphaeriales. An attempt is made here to organize and to complete, where possible, the scattered and often unrelated or incomplete data concerning the Indiana species of the family Xylariaceae, and to present it in such a manner that it will form a workable basis for future taxonomic investigation or for classroom determination of collections.

During the preparation of this study specimens were available from the following institutions: DePauw University (DPU)[2]; Indiana University (IU); Miami University (MU); Division of Mycology and Disease Survey of the Bureau of Plant Industry, U. S. Department of Agriculture (BPI); and Wabash College (WAB).

Sincere appreciation is acknowledged to the following persons who assisted the author in locating either herbarium material or literature: Doctor A. R. Bechtel, Wabash College; Doctors R. E. Cleland and Paul Weatherwax, Indiana University; Doctor C. L. Porter, Purdue University; Howard Youse, DePauw University; Miss Nellie M. Coats, Librarian of the Indiana Academy of Science Library; and various staff members of the Lloyd Library and Museum and of the libraries of the Farlow Herbarium at Harvard University, the Philadelphia Academy of Sciences, Indiana University, University of Illinois, and Purdue University.

Particular indebtedness is acknowledged to Doctor Truman G. Yuncker and to Doctor Winona H. Welch of the Botany Department of DePauw University whose resources of information, advice, and friendly encouragement were made freely available to the author throughout the course of his work.

XYLARIACEAE

Xylarieae Winter, in Rabenhorst, *Kryptogamen-Flora.* 1 (Div. II) : 842. 1887.

Xylariaceae Lindau, in Engler and Prantl, *Die Natürlichen Pflanzenfamilien.* 1 (Div. I) : 480. 1897.

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[1] A portion of a major thesis (A Monographic Study of the Indiana Species of the Stromatic Sphaeriales) presented to the Faculty of the Department of Botany, DePauw University, in partial fulfillment of the requirements for the degree Master of Arts, June 1946.

[2] These abbreviations are used in locating specimens referred to in the citations following each species description throughout this paper.

Stromata quite variable in form and size, mostly free, but often more or less sunken in the matrix; either upright and often branched or horizontal, effused, crustaceous, pulvinate, globose, or hemispherical, mostly black or becoming black, of woody, carbonaceous or suberose-carnose consistence. In Rosellinia the stroma exists as a thin sterile wall of dark fungal tissue surrounding each separate perithecium. Young stromata clothed with a conidial layer. Perithecia membranaceous, seated under a more or less well-developed ectostroma, with the bases in entostromatic tissue. A subiculum often present. Asci long cylindrical; stalks long and filiform, or short with asci almost sessile. Asci lining the bases and sides of the perithecia. Paraphyses thread-like, branched, completely filling the perithecial cavity at an early period and more or less gelatinizing at maturity. Ascospores unicellular, light brown to black, inequilaterally elliptical, fusoid, or globose, uniseriate in the ascus. Conidiophores hyphomycetous, covering the exposed ectostroma, branched. Conidia single or in clusters, minute, borne apically and becoming lateral by the continued growth of the conidiophore.

KEY TO THE GENERA

1. Perithecia single to aggregate, superficial ..... *Rosellinia*
   Perithecia several to many in a stroma 2
2. Stroma stalked, simple to branched, base sterile ..... *Xylaria*
   Stroma effuse, pulvinate to globose, sessile 3
3. Entostromatic zonation prominent ..... *Daldinia*
   Entostromatic zonation lacking or inconspicuous 4
4. Stroma becoming more or less hollow at maturity ..... *Ustulina*
   Stroma mostly entirely persistent 5
5. Stroma orbicular, cup-shaped, or discoid ..... *Nummularia*
   Stroma otherwise (globose, pulvinate, or effused) ..... *Hypoxylon*

DALDINIA Cesati & DeNotaris

Daldinia Cesati & DeNotaris, Schema Sfer. Ital. 4:197. 1863.

Stromata superficial, hemispherical, subglobose, globose, or turbinate; sessile, substipitate, or stipitate. Ectostroma carbonaceous, at first pruinose, later dull black, shining, or laccate. Entostroma dense or lacunate, white, gray, or brown; conspicuously concentrically zonate. Perithecia claviform to subglobose, immersed in the stroma; ostiola obsolete to protruding. Asci cylindrical, soon disappearing, 8-spored, the spores obliquely uniseriate. Ascospores simple, ellipsoid to navicular, light to dark brown.

KEY TO THE SPECIES

Entostroma persistent ..... 1. *D. concentrica*
Entostroma collapsing, loculate ..... 2. *D. vernicosa*

1. *Daldinia concentrica* (Bolton) Cesati & DeNotaris

Valsa tuberosa Scopoli, Fl. Carniolica, ed. 2, 2:399. 1722.

Lycoperdon fraxineum Hudson, Fl. Angl. 2:641. 1778.

Sphaeria concentrica Bolton, Hist. Fung. Halifax, 3:180. 1789.

Sphaeria tunicata Tode, Fungi Meckl. Sel. 2:59, pl. 17, fig. 130. 1791.

Lycoperdon atrum Schaeffer, Icon. Fung. Bav. et Pal. 4:131, pl. 329. 1800.

Sphaeria fraxinea Withering, Arrang. Brit. Pl., ed. 5, 4:429. 1812.

Sphaeria hemisphaericae Nees, Syst. d. Pilze, 1:291. 1817.

Sphaeria concentrica Bolton, in Fries, Syst. Mycol. 2:331. 1823.

Stromatosphaeria concentrica Greville, Fl. Edinensis, 355. 1824.

Sphaeria placenta Link, Linnaea, 5:539-540. 1830.

Hemisphaeria concentrica Klotzsch, Acad. Caes. Leop. Nova Acta, 19:241. 1843.

Daldinia concentrica (Bolton) Cesati & DeNotaris, Schema Sfer. Ital. 4:197. 1863.

Stromata hemispherical to globose, sessile to stipitate, single or coalescing, 1-10 cm. long x 1-7 cm. wide x 1-7 cm. tall, rubiginous when young, erumpent from the bark or superficial on decorticated wood. Ectostroma moderately thin, dark brown, later becoming black and either dull or shiny. Entostroma densely fibrous, persistent, conspicuously concentrically zoned, the lighter zones up to three times wider than the darker zones. Perithecia usually monostichous, rarely polystichous, claviform to subclaviform. Ostiola punctiform to somewhat prominent. Ascospores inequilaterally ellipsoid, brown, the ends sometimes of a lighter color and more refractive, mostly 12-14 x 5-7 microns. Specimens examined:

Clark Co.: on mulberry, Borden, Nov. 2, 1908, *J. M. Van Hook 2435* (IU).

Jasper Co.: on decaying stump, Fountain Park woods, one mile north of Remington, July 11, 1935, *Winona H. Welch* (DPU).

Knox Co.: on slabs of bark from lumber yard, in an apple orchard, near Vincennes, Oct. 20, 1934, *M. A. Byers* (DPU).

Monroe Co.: Bloomington, Nov. 12, 1908, *J. M. Van Hook 2468* (IU).

Montgomery Co.: on old log, in woods near Crawfordsville, Aug. 24, 1917, *Bruce Fink 175* (MU); near crinoid beds, Crawfordsville, March 18, 1910, *J. Schraum* and *H. W. Anderson* (WAB).

Putnam Co.: on decaying log, along Mill Creek, Hoosier Highlands, June 3, 1936, *Winona H. Welch 2249* (DPU); Greencastle, 1932-1933, *F. Shuttleworth* (DPU); on dead wood, in cleared woods south of Greencastle, Oct. 9, 1935, *H. Youse 23* (DPU); on decaying log, DePauw Arboretum, Oct. 25, 1945, *Simmons 1130* (DPU); on decaying branches, DePauw Arboretum, Oct. 25, 1945, *Simmons 1131* (DPU); on fallen beech log, Fern, Oct. 12, 1945, *Simmons 1132* (DPU); on fallen log of Ulmus sp., Fern, Oct. 12,

1945, *Simmons 1133* (DPU); on fallen log, Hoosier Highlands, Sept. 16, 1941, *Simmons 1134* (DPU).

Scott Co.: Scottsburg, 1907, *J. R. Weir 8964* (BPI); on *Hicoria ovata*, May 1901, *J. R. Weir 2751* (BPI); on *Hicoria ovata*, June 1912, *J. R. Weir 7433* (BPI).

The macroscopic appearance of the fruiting structures of this species is fairly constant except that when it is found growing on very porous or decaying wood the fruiting structures often attain an abnormally greater size. *D. concentrica* (Bolt.) Ces. & DeN. is of common occurrence in Indiana and is readily identified by means of its fibrous, persistent, concentrically zoned entostroma.

2. *Daldinia vernicosa* (Schweinitz) Cesati & DeNotaris

Hypoxylon concentricum (Bolton) Fries var. *obovatum* Fries, Syst. Mycol. 2:331. 1823.

Sphaeria vernicosa Schweinitz, Journ. Acad. Sci. Phil. 5:9. 1825.

Sphaeria cingulata Léveillé, Ann Sci. Nat. Bot. 3:47. 1845.

Daldinia vernicosa (Schweinitz) Cesati & DeNotaris, Comm. della Soc. Critt. Ital. 1:198. 1863.

Hypoxylon vernicosum (Fries) Berkeley & Curtis, Journ. Linn. Soc. Bot. 10:384. 1867.

Daldinia cingulata (Léveillé) Saccardo, Syll. fung. 1:395. 1882.

Daldinia fissa Lloyd, Mycol. Writings, 7:1313. 1924.

Stromata subturbinate to turbinate, contracted below into a distinct rugose stipe with annular zones externally visible, stromata usually single, occasionally confluent, fragile, 0.6-3.5 cm. long x 0.5-2.5 cm. wide x 0.8-2.5 cm. tall. Entostroma conspicuously zonate, the lighter zones usually gray-white or yellowish-gray, fibrous, collapsing and loculate, 2-4 times broader than the darker and more persistent brown to black zones. Ectostroma thin and carbonaceous, brittle, at first brown, finally shiny or laccate and black. Perithecia monostichous or polystichous, ovoid-oblong to subglobose. Ostiola punctiform to somewhat prominent. Ascospores usually brown to dark brown, the ends obtusely rounded, mostly 11-13 x 5-7 microns. Conidia single or in whorls, subglobose to ovoid, hyaline, 2.5-3 x 2.5-3 microns.
Specimens examined:

Decatur Co.: on hardwood trunk, Sandusky, Aug. 17, 1912, *M. C. Jensen* (BPI).

Scott Co.: on dead *Quercus alba*, Scottsburg, 1908, *J. R. Weir 21070* (BPI).

This species is easily distinguished from *D. concentrica* (Bolt.) Ces. & DeN. by reason of the more distinctly stipitate nature of the fruiting body and the loculate, collapsing appearance of the entostroma.

HYPOXYLON Fries

Hypoxylon Fries, Summa Veg. Scand. 383. 1849.

Penzigia Saccardo, Mycol. Malac. 20. 1888.

Alboffia Spegazzini, An. Mus. Nac. 1:295. 1899.

Squamotubera Hennings, Hedwigia, 42:(308). 1903.

Spirogramma Ferd. & Wing., Vid. Med. For. Kjob. 142. 1909.

Theissenia Maublanc, Bull. Soc. Mycol. Fr. 30:52. 1914.

Pyrenopolyporus Lloyd, Mycol. Notes, 50:76. 1917.

Entoleuca Sydow, Ann. Mycol. 20:186. 1922.

Stromata globose to pulvinate to effused, erumpent, leathery, woody, or carbonaceous when mature. Perithecia several to many in a stroma. Asci cylindrical, arranged on sides and bottom of perithecia, 8-spored. Paraphyses numerous, thread-like. Ascospores brown to black, with an elongate, hyaline depression, uniseriate in the ascus. Conidial layer formed first on an exposed ectostroma, later developing on old stromata in favorable weather. Conidiophores branched, hyphomycetous, hyaline to greenish-brown; conidia minute, borne apically, becoming lateral by the sympodial growth of the hypha.

KEY TO THE SPECIES

1. Ostiola umbilicate or punctiform; stroma usually woody with red to purple ectostroma and dark-colored entostroma 2
   Ostiola annulate; stroma carbonaceous, black 6
   Ostiola papillate; entostroma thick, carbonaceous or fibrous to thin, almost lacking 9
2. Stroma globose, subglobose, or hemispherical 3
   Stroma effused 5
3. Ascospores 8 microns long or less ..... 8. *H. Howeianum*
   Ascospores more than 8 microns long 4
4. Stroma subglobose to globose; asci (sp. p.)[3] 55-75 microns long ..... 3. *H. coccineum*
   Stroma hemispherical to depressed-pulvinate; asci (sp. p.) 75-90 microns long ..... 7. *H. fuscum*
5. Ostiola prominently white-margined; ectostroma rusty purple ..... 14. *H. perforatum*
   Ostiola margins not differing in color from other stromatic material; ectostroma bright red to reddish-brown ..... 16. *H. rubiginosum*
6. Stroma semipulvinate to hemispherical 7
   Stroma effused 8

[3] sp. p. is used here to indicate measurements of the spore-containing portion of the ascus.

7. Perithecia small (0.5 mm.), deeply and evenly sunken in the substance of the stroma ..... 11. *H. marginatum*
   Perithecia larger (0.7-1 mm.), prominent, many projecting half their length beyond the surface of the stroma ..... 1. *H. annulatum*
8. Asci (sp. p.) 50-60 microns long ..... 5. *H. effusum*
   Asci (sp. p.) 60-70 microns long ..... 1. *H. annulatum*
9. Perithecia sunken in the substratum ..... 12. *H. Morsei*
   Perithecia not sunken in the substratum 10
10. Stroma large (3-4 x 2.5-3 cm.), centrally attached, surface in folds or ridges ..... 15. *H. Petersii*
    Stroma not entirely as above; may be globose, hemispherical, turbinate, or variously effused 11
11. Stroma globose, hemispherical, turbinate or pulvinate 12
    Stroma variously effused 14
12. Ascospores 9 microns or less in length ..... 17. *H. Sassafras*
    Ascospores more than 9 microns in length 13
13. Stroma hemispherical, globose, or turbinate ..... 4. *H. cohaerens*
    Stroma usually elliptical and depressed-pulvinate ..... 13. *H. multiforme*
14. Stroma broadly effused 15
    Stroma in small effused patches, rarely exceeding 2 cm. in any dimension except by confluence 18
15. Ectostroma white ..... 2. *H. atropunctatum*
    Ectostroma black or becoming black at maturity 16
16. Ascospores 20-28 microns long ..... 19. *H. stigmateum*
    Ascospores less than 20 microns long 17
17. Perithecia regularly oblong, densely crowded ..... 10. *H. investiens*
    Perithecia globose, prominent ..... 13. *H. multiforme*
18. Ascopores mostly 8 microns long ..... 9. *H. insidens*
    Ascospores more than 9 microns long 19
19. Ascospores mostly 9 x 3.5 microns ..... 6. *H. epirrhodium*
    Ascospores 12-16 x 5-6 microns ..... 18. *H. serpens*

1. *Hypoxylon annulatum* (Schweinitz) Montagne

Sphaeria annulata Schweinitz, in Fries, Elench. Fung. 2:64. 1828.
Hypoxylon annulatum (Schweinitz) Montagne, Syll. Crypt. 213. 1856.

Stromata hemispherical (when growing from bark) or indeterminately effused (when on decorticated wood). Young stromata dark brown, at maturity black, hard, carbonaceous. Ectostroma loose and subiculum-like (on wood), formed by coalescence of the mycelium arising from ascospores. Perithecia large, nearly globose, about 1 mm. in diameter. Apices of perithecia flattened into a truncate disk with the papillate ostiolar necks in the center. Asci cylindrical, 95-110 microns long, sp. p. 60-70 microns long. Ascospores uniseriate in asci, inequi-

laterally elliptical, 7-9 x 3-4 microns, dark brown at maturity. Conidial layer arising from ectostroma as a thick, brown subiculum. Conidiophores much branched.

Specimens examined:

Monroe Co.: on ash, Bloomington, Jan. 17, 1914, *Ramsey* (IU); on oak, Unionville, Nov. 12, 1910, *Owens* (IU).

Putnam Co.: on dead poplar, Greencastle, Oct. 12, 1907, *Banker* (DPU); Fern, April 1893, *L. H. Underwood* (DPU); on rotten beech stump, Greencastle, Jan. 22, 1908, *Daisy G. Lewis* (DPU); on dead log, Limedale, March 26, 1933, *Ray Dawson 76* (DPU).

Wabash Co.: on elm stump, Roann, March 23, 1908, *Daisy G. Lewis* (DPU).

H. annulatum (Schw.) Mont. is a fairly common Indiana species. The annulate-truncate nature of the perithecia is usually well-defined although the stromata may vary in form from hemispherical to effused. The perithecia of this species, in contrast to the small, evenly immersed perithecia of *H. marginatum* (Schw.) Berk., are noticeably large and prominent. Comparison of specimens of *H. annulatum* and of *H. effusum* Nke. reveals that the former has more prominent annular disks and longer asci, for the most part, than does the latter.

2. *Hypoxylon atropunctatum* (Schweinitz) Cooke

Sphaeria atropunctata Schweinitz, Syn. fung. Car. 5. 1822.

Anthostoma atropunctatum Saccardo, Syll. fung. 1:295. 1882.

Hypoxylon atropunctatum (Schweinitz) Cooke, Grevillea, 13:15. 1884.

Stromata white, punctate with black ostiolar papillae, widely effused, circumscribed by a black line. Ectostroma white, hard, carbonaceous. In old stromata the white layer peels off entirely or in patches leaving a black entostroma exposed. Entostroma very thin, black, leaving perithecia almost in contact with the wood. Perithecia globose to flask-shaped, 200-300 microns in diameter, in a single layer, not crowded. Ostiola papillate. Asci 150-160 x 12-14 microns with very short stalks. Ascospores uniseriate, 25-30 x 11-14 microns, black at maturity, elliptical with pointed ends. Paraphyses filiform. Conidiophores very long and branched, producing masses of globose conidia 5-6 microns in diameter.

Specimens examined:

Monroe Co.: on oak, Unionville, Nov. 12, 1910, *Owens* (IU); on beech, *J. M. Van Hook 2438* (IU).

Montgomery Co.: on oak stump, in open wood near Crawfordsville, July 27, 1917, *Fuson 100* (MU).

Orange Co.: on beech, March 26, 1910, *Owens* (IU).

The white ectostroma of specimens of *H. atropunctatum* (Schw.) Cke. is a prominent and constant character which readily distinguishes it from mature specimens of other Indiana members of the genus.

3. *Hypoxylon coccineum* Bulliard

Hypoxylon coccineum Bulliard, Hist. Champ. Fr. 174. 1791.

Stromata erumpent-superficial, subglobose, generally 0.25-0.75 cm. in diameter, deep brick-red when mature, often paler when young, solitary or subconfluent. Perithecia peripherical in a single layer, small, subglobose, slightly prominent. Ostiola umbilicate or punctiform. Asci cylindrical, sp. p. 55-75 x 6-7 microns. Ascospores uniseriate, opaque, inequilaterally elliptical, 9-12 x 4-5 microns. Paraphyses abundant, simple.

Specimens examined:

Brown Co.: on beech, Trevlac, Oct. 13, 1908, *Burger* (IU).

Monroe Co.: on beech, Unionville, Nov. 7, 1910, *Owens* (IU); on beech, Bloomington, Fall 1907, *J. M. Van Hook* (IU).

Montgomery Co.: on *Fagus sp.*, Summer 1928, *A. R. Bechtel* (IU); on beech bark, Crawfordsville, Spring 1929, *A. R. Bechtel 832* (WAB); at Shades Park, Oct. 2, 1910, *M. B. Thomas* (WAB); Turner's Woods, near Crawfordsville, May 21, 1941, *Simmons 1102* (DPU); on fallen branches, Offield Creek, S. W. Crawfordsville, Nov. 25, 1940, *D. Yoder* (DPU).

Owen Co.: on maple, State Park, December 1930, *Martens* (IU).

Parke Co.: on dead branch, Turkey Run State Park, Nov. 22, 1940, *L. Lee* (DPU).

Putnam Co.: Fern, November 1892, *L. M. Underwood* (DPU); on decaying tree branch, in ravine over stream 1-2 miles N. W. Greencastle, April 8, 1943, *Winona H. Welch 9004* (DPU); on fallen beech log, Fern, Oct. 12, 1945, *Simmons 1181* (DPU); on bark of fallen log, shaded ravine, Hoosier Highlands, Sept. 16, 1941, *Simmons 1187* (DPU); on fallen beech limb, in valley E. Bainbridge, Oct. 17, 1941, *Simmons 1210* (DPU); on bark of dead limb, ravine near Depauw Arboretum, Oct. 14, 1941, *Simmons* (DPU); on rotting bark, in ravine, Hoosier Highlands, Sept. 16, 1941, *Simmons 1192* (DPU).

Ripley Co.: on *Quercus sp.*, April 5, 1931, *Busteed* (IU).

Wabash Co.: on dead beech log, Roann, March 20, 1908, *Daisy G. Lewis* (DPU).

H. coccineum Bull. is one of the most commonly collected species of Hypoxylon. The bright brick-red color of the ectostroma sets it off from other subglobose members of the genus except *H. Howeianum* Peck. The entostromatic tissue of *H. coccineum* is homogeneous in structure and of a gray-black color. That of *H. Howeianum* is radiate-fibrous in structure with faint concentric rings and blue-black in color. The length of ascospores of *H. Howeianum* (6-8 microns) is measurably less than that of *H. coccineum.*

4. *Hypoxylon cohaerens* (Persoon) Fries

Sphaeria cohaerens Persoon, Syn. meth. fung. 11. 1801.

Sphaeria turbinulata Schweinitz, Syn. fung. N. Am. 192. 1831.

Hypoxylon cohaerens (Persoon) Fries, Summa Veg. Scand. 42. 1849.

Hypoxylon turbinulatum (Schweinitz) Ellis & Everhart, N. Am. Pyr. 636. 1892.

Stromata erumpent-superficial, 2-4 mm. in diameter, gregarious or crowded and often confluent, hemispherical or globose, mostly flattened above, at first dirty-brown, becoming nearly black. Perithecia in a single layer, 6-10 in a stroma, rather large and distinctly prominent with papilliform ostiola. Asci cylindrical, 8-spored, sp. p. 40-68 x 5-6 microns. Ascospores uniseriate, ovate, inequilateral, brown, 10-12 x 4-6 microns. Conidial hymenium clothing the young stromata, of a pale clay color, becoming cinereous. Conidia obovate-subglobose, very small.

Specimens examined:

Brown Co.: on beech, Oct. 22, 1908, *J. M. Van Hook* (IU); on American beech in brushpile, on earthen dam of Ogle Lake, Brown County State Park, Oct. 21, 1945, *Winona H. Welch 9003* (DPU).

Clark Co.: on beech, Borden, Nov. 2, 1908, *J. M. Van Hook 2410* (IU).

Monroe Co.: on beech, Unionville, Nov. 12, 1910, *Owens* (IU); on beech, S. E. Bloomington, March 4, 1911, *Owens* (IU).

Montgomery Co.: on bark, Crawfordsville, *Hudersons* (MU); on dead, decaying limb of *Fagus sp.*, Camp Rotary, October 1945, *A. R. Bechtel* (DPU).

Parke Co.: on old log, Turkey Run State Park, Oct. 27, 1945, *T. G. Yuncker 11920* (DPU); on dead beech wood, Turkey Run State Park, Nov. 21, 1940, *L. Lee* (DPU); on dead wood, Turkey Run State Park, Sept. 17, 1940, *L. Lee* (DPU); on fallen beech log, Turkey Run State Park, Nov. 2, 1940, *L. Lee* (DPU).

Putnam Co.: on dead decorticated wood, in ravine, Hoosier Highlands, Sept. 16, 1941, *Simmons 1189* (DPU); on cork of dead log, Hoosier Highlands, Sept. 16, 1941, *Simmons 1202* (DPU); on rotting beech log, Fern, Oct. 12, 1945, *Simmons 1217* (DPU); on beech log, Greencastle, May 27, 1908, *Daisy G. Lewis* (DPU), originally determined as *H. Ravenelii* Rehm; on beech log, 3 mi. W. Greencastle, May 14, 1946, *Winona H. Welch 9016* (DPU); on beech log, 3 mi. W. Greencastle, May 14, 1946, *Winona H. Welch 9015* (DPU).

Miss Lewis determined her above-cited collection as *H. Ravenelii* Rehm, but this specimen agrees both in macroscopic appearance and in spore measurements with our descriptions of *H. cohaerens* (Pers.) Fr. The fruiting structures of *H. cohaerens* may vary in shape from sessile, hemispherical to turbinate. This species may be distinguished from *H. Sassafras* (Schw.) Berk. by reason of its longer ascospores (10-12

microns in contrast to 7-9 microns for *H. Sassafras*). Schweinitz recognized the turbinate forms of this species as *Sphaeria turbinulata*[4] and Ellis and Everhart continue this separation with their *H. turbinulata* (Schw.) E. & E.[5] *H. turbinulata*, as described by Ellis and Everhart, differs from *H. cohaerens* only in the substipitate appearance of the stroma and can be only an accentuated growth form of the latter. The two are considered as synonyms by C. L. Shear.[6] The present writer concurs in this opinion.

5. *Hypoxylon effusum* Nitschke

Hypoxylon effusum Nitschke, Pyr. Germ. 48. 1867.

Stromata indefinitely effused, convex, carbonaceous, black at maturity, dotted by the exposed annular disks surrounding the ostiola. In old stromata the ectostroma wears off leaving the perithecia exposed. Entostroma scarcely developed. Asci cylindrical, attenuated into a stalk, 80-100 microns long, sp. p. 50-60 microns long. Ascospores uniseriate, 5-8 x 3-3.5 microns, pale brown at maturity.

Specimens examined:

Monroe Co.: on rotten *Quercus sp.*, Nov. 20, 1913, *Ramsey* (IU); on elm, Bloomington, Jan. 7, 1911, *Owens* (IU).

Putnam Co.: on dead log, near Big-Four Springs, Greencastle, April 13, 1908, *Daisy G. Lewis* (DPU).

This species, because of the annular stromatic disks around the ostiola and the effused habit of the stroma, generally is not confused with other species of Hypoxylon except *H. annulatum* (Schw.) Mont. In this case, however, the annular disks of *H. effusum* are seen to be less pronounced than in specimens of *H. annulatum* and the average ascus length is less (sp. p. 50-60 microns against 60-70 microns for *H. annulatum*).

6. *Hypoxylon epirrhodium* Berkeley & Ravenel

Hypoxylon epirrhodium Berkeley & Ravenel, Grevillea, 4:51. 1875.

Stromata black, effused, thin, forming dark patches about 4 mm. across, papillose from the slightly prominent ostiola. Asci linear. Ascospores uniseriate, elliptical, 9 x 3.5 microns.

Specimens examined:

Putnam Co.: on dead wood, near Big-Four Springs, Greencastle, May 27, 1908, *Daisy G. Lewis* (DPU).

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[4] Lewis David von Schweinitz, "Synopsis fungorum in America Borealis media degentium," *Trans. Amer. Phil. Soc.* **4**:192, 1831.

[5] J. B. Ellis and B. H. Everhart, *The North American Pyrenomycetes.* Newfield, New Jersey: Ellis and Everhart, 1892, p. 636.

[6] Cornelius L. Shear, *Mycologia,* **20**:84. 1928.

Conclusive identification of *H. epirrhodium* Berk. & Rav. depends largely on spore measurements. It is classed among those species which produce small, effused patches of stromatic tissue, as do *H. insidens* (Schw.) E. & E. and *H. serpens* (Pers.) Fr. As is indicated in the key to Hypoxylon, separation of these three very similar species is possible by means of observations of variation in spore characters.

7. *Hypoxylon fuscum* (Persoon) Fries

Sphaeria fragiformis Hoffmann, Veg. Crypt. 1:20. 1787.

Sphaeria confluens Willdenow, Flora Berol. 416. 1787.

Sphaeria tuberculosa Bolton, Fungi Hal. 3:123. 1789.

Sphaeria castorea Tode, Fungi Meckl. 2:28. 1791.

Sphaeria fusca Persoon, Syn. meth. fung. 12. 1801.

Sphaeria Coryli DeCandolle, Flora Franc. 2:287. 1805.

Sphaeria glomerata DeCandolle, Flora Franc. 2:287. 1805.

Hypoxylon fuscum (Persoon) Fries, Summa Veg. Scand. 384. 1849.

Stromata erumpent-superficial, solitary or subconnate, depressed-pulvinate or hemispherical, generally 1-3 mm. in diameter, dark purplish-red, finally black, somewhat uneven from the slightly projecting perithecia. Perithecia small, closely packed, slightly projecting, irregularly monostichous, subglobose, with minute, mammilliform ostiola. Asci cylindrical, on long pedicels, sp. p. 75-90 x 5-6 microns. Paraphyses filiform. Ascospores uniseriate, subinequilaterally elliptical, opaque, 11-14 x 5-6 microns. Conidia very minute, borne singly at the extremities of short, sparingly branched sterigmata.

Specimens examined:

Monroe Co.: on *Ostrya sp.*, Bloomington, 1911, *Martin* (IU); on elm, Bloomington, 1911, *Owens* (IU); on water beech, Unionville, Nov. 12, 1910, *Owens* (IU).

Montgomery Co.: on bark, at the Shades, Sept. 6, 1913, *H. W. Anderson* (MU, WAB); on beech stump, Durhams' Wood, July 22, 1917, *Sylvia Fuson 99* (MU).

Morgan Co.: on dead limb, ravine N. E. Martinsville, Sept. 20, 1941, *Simmons 1212* (DPU).

Parke Co.: on dead bark, Turkey Run State Park, Nov. 22, 1940, *L. Lee* (DPU).

Putnam Co.: on rotting beech log, Fern, Oct. 12, 1945, *Simmons 1244* (DPU); on dead bark of *Carpinus sp.*, E. Bainbridge, Nov. 14, 1945, *Simmons 1205* (DPU); on bark of *Quercus sp.*, E. Bainbridge, Nov. 14, 1945, *Simmons 1206* (DPU); on dead *Fagus sp.*, DePauw Arboretum, Oct. 25, 1945, *Simmons 1245* (DPU); on cork of dead log, Hoosier Highlands, Sept. 16, 1941, *Simmons 1201* (DPU); on bark of dead limb, DePauw Arboretum, Nov. 18, 1941, *Simmons 1229* (DPU).

Scott Co.: on *Alnus glutinosa*, Weirtown, 1904, *J. R. Weir 20054* (MU).

This common species usually is determined readily by reason of its pulvinate to hemispherical and dark purplish-red stromata. It rarely will be confused with hemispherical specimens of *H. Howeianum* Peck which often become nearly black at maturity. A comparison of ascospore measurements (*H. fuscum* 11-14 x 5-6 microns; *H. Howeianum* 6-8 x 3-3.5 microns) will facilitate making a distinction between the two species.

8. *Hypoxylon Howeianum* Peck

Hypoxylon Howeianum Peck, 24th Rep. N. Y. St. Mus. 98. 1871.

Stromata globose to hemispherical and symmetrical except when compressed by adjacent ones; never effused or pulvinate. Most stromata 3-12 mm. in diameter and 3-8 mm. thick, fleshy to woody, not carbonaceous. Ectostroma bright brick-red which darkens to almost black in very old specimens. Perithecia monostichous, borne in the periphery of the stroma, not erumpent through the stroma. Ostiola umbilicate, the ectostroma being slightly raised over each perithecium. Periphyses delicate, lining the ostiola. Asci thin, hyaline, 80-100 microns long, sp. p. 50-60 microns long. Paraphyses very delicate and branched, completely filling the centrum. Ascospores 6-9 microns long, light brown, uniseriate in the ascus. Conidia minute, 4-6 microns in diameter, globose to oblong, hyaline, borne in clusters of one to several on lateral branches.

Specimens examined:

Monroe Co.: on beech, Bloomington, 1908, *J. M. Van Hook 2245* (IU).

Putnam Co.: on dead limb, near Fern, April 17, 1908, *Daisy G. Lewis* (DPU); on bark of dead *Platanus sp.*, E. Bainbridge, Nov. 14, 1945, *Simmons 1203* (DPU).

The radiate-fibrous and faintly concentrically zonate entostroma and the shorter ascospores of *H. Howeianum* Peck serve to distinguish it from *H. coccineum* Bull., which usually produces an homogeneous, gray-black entostroma. Distinctions between *H. Howeianum* and *H. coccineum* often are difficult to make out, and for this reason some mycologists consider the two species as being identical.

9. *Hypoxylon insidens* (Schweinitz) Ellis & Everhart

Sphaeria insidens Schweinitz, Syn. fung. Car. 13. 1822.

Fuckelia insidens (Schweinitz) Cooke, Grevillea, 12:52. 1884.

Hypoxylon insidens (Schweinitz) Ellis & Everhart, N. Am. Pyr. 653. 1892.

Stromata innate, effused, nearly round, brown-black, partly sterile, apparently superficial but the base immersed in the matrix and surrounded by a faint circumscribing line. Perithecia more or less prominent, subpapillate. Asci cylindrical. Ascospores uniseriate, elliptical, pale brown, 8 x 4 microns.

Collection of this species in Indiana (Montgomery County) is reported by Fink & Fuson,[7] but their specimen is not found among others of their collections deposited in the herbarium of Miami University. *H. insidens* (Schw.) E. & E. is included in this study on the basis of the report of Fink and Fuson. This is one of the Hypoxylon species which produces small, effused patches of stromatic tissue. According to its description, it may be distinguished from similar species by reason of its small (usually 8 x 4 microns) ascospores.

10. *Hypoxylon investiens* (Schweinitz) Berkeley

Sphaeria investiens Schweinitz, Syn. fung. N. Am. 193. 1831.
Hypoxylon investiens (Schweinitz) Berkeley, Journ. Linn. Soc. 10:385. 1869.

Stromatic material very scanty, covering the perithecia with a thin, black stratum, mammillose above from the slightly projecting perithecia. Perithecial layer seated on a thick sterile crust of entostroma that spreads over and blackens the wood following all the inequalities of the surface. Surface of the stroma with a distinct purplish tinge. Perithecia densely crowded in a single series, the regularly oblong perithecia forming a continuous layer about 0.75 mm. thick and 4-9 cm. long and wide. Ostiola papilliform, deciduous. Ascospores oblong, pale brown, 6-10 (mostly 6-8) x 3-4 microns.

Specimens examined:

Putnam Co.: on rotten stump, N. E. Greencastle, March 25, 1908, *Daisy G. Lewis* (DPU).

H. investiens (Schw.) Berk. closely resembles the effused forms of *H. multiforme* Fr. However, the perithecia of *H. investiens* are compressed-oblong and slightly projecting above while those of *H. multiforme* are globose and distinctly prominent.

11. *Hypoxylon marginatum* (Schweinitz) Berkeley

Sphaeria durissima Schweinitz, Syn. fung. Car. 6. 1822.
Sphaeria truncata Schweinitz, Syn. fung. Car. 18. 1822.
Sphaeria marginata Schweinitz, Syn. fung. N. Am. 190. 1831.
Hypoxylon marginatum (Schweinitz) Berkeley, Grevillea, 4:49. 1875.
Hypoxylon durissimum (Schweinitz) Cooke, Grevillea, 11:131. 1883.

Stromata at maturity black, semipulvinate to hemispherical, variable in form, 1-4 cm. in diameter and 2-10 mm. thick; never flat and effused. Young stromata olivaceous-green inside and darker on the outside with a green tint, nearly globose, with an even surface, perithecia breaking through the ectostroma late in its development. Entostroma

[7] Bruce Fink and Sylvia Fuson, "An Arrangement of the Ascomycetes of Indiana," *Proc. Ind. Acad. Sci.* 28:127, 1919.

always well developed. Ectostroma slightly roughened by the annular depressions around the ostiola. Asci cylindrical, 105-125 microns long, sp. p. 65-75 microns long. Ascospores uniseriate, slightly inequilaterally elliptical, 7-9 x 3-4 microns, opaque at maturity. Conidia hyaline to greenish-hyaline, 3 x 4 microns. Conidial layer greenish.

Specimens examined:

Clark Co.: on oak, Borden, Nov. 2, 1908, *J. M. Van Hook 2412* (IU).

Monroe Co.: on oak, Bloomington, Feb. 4, 1911, *Owens* (IU).

Parke Co.: on beech, Turkey Run State Park, May 19, 1932, *Martens* (IU); on bark, Turkey Run State Park, Nov. 15, 1940, *L. Lee* (DPU).

Ripley Co.: on *Quercus sp.*, April 5, 1931, *Busteed* (IU).

H. marginatum (Schw.) Berk. is a fairly common Indiana species which often resembles the effused forms of *H. annulatum* (Schw.) Mont. The perithecia of *H. marginatum* are small (0.5 mm. in diameter) and evenly sunken in the stromatic tissue while those of *H. annulatum* are larger (0.7-1 mm. in diameter) and projecting above the surface of the stroma.

12. *Hypoxylon Morsei* Berkeley & Curtis

Hypoxylon Morsei Berkeley & Curtis, Grevillea, 4:51. 1875.

Hypoxylon Blakei Berkeley & Curtis, Grevillea, 4:52. 1875.

Hypoxylon pauperatum Karsten, Enum. Fungi Lapp. 8:211. 1882.

Sphaeria mammata Nylander, Not. pro Fauna et Flora Fenn. 88. 1923.

Stromata erumpent, orbicular, 3-5 mm. in diameter, flattened above, brownish-black, composed of 5-10 perithecia. Ectostroma thin, covering the perithecia. Entostroma lacking or nearly so. Perithecia large (about 1 mm. in diameter), globose, flattened on top, sunken in the wood substratum. Ostiola papillate. Asci cylindrical, 160-200 microns long, sp. p. 120-140 microns long. Ascospores uniseriate, elliptical, with rounded to acute ends, 17-22 x 8-10 microns, brown.

Specimens examined:

Montgomery Co.: on *Rhus vernix*, Elmdale, April 15, 1929, *A. R. Bechtel* (IU); on *Rhus vernix*, Cranberry Bog near Elmdale, Spring 1929, *A. R. Bechtel 830* (WAB).

This species is the only papillate Hypoxylon reported for Indiana which typically has its perithecia sunken in the wood. Entostromatic tissue is lacking, or nearly so, in this species thus allowing the perithecia to come in close contact with the tissues of the substratum.

13. *Hypoxylon multiforme* Fries

Hypoxylon granulosum Bulliard, Hist. Champ. Franc. 176. 1791.

Sphaeria rubiformis Persoon, Syn. meth. fung. 9. 1801.

Sphaeria peltata DeCandolle, Flora Franc. 2:287. 1805.

Sphaeria multiformis Fries, Syst. Mycol. 2:334. 1823.

Sphaeria atropurpurea Fries, Syst. Mycol. 2:340. 1823.

Hypoxylon multiforme Fries, Summa Veg. Scand. 384. 1849.

Hypoxylon atropurpureum Fries, Summa Veg. Scand. 384. 1849.

Stromata erumpent and often margined by the ruptured bark, of various shapes but usually transversely elongated, oblong or elliptical, somewhat flattened above, 1-1.5 cm. long by 0.5-0.75 cm. wide or, by confluence, broadly effused, dull rusty-red at first, finally black and smooth. Perithecia irregularly monostrichous, rather large, globose, distinctly prominent, with papilliform ostiola. Asci cylindrical, on long stalks, sp. p. 60-90 x 6-8 microns. Paraphyses simple, slender, longer than asci. Ascospores uniseriate, inequilateral-oblong, pale brown, 9-14 x 3.5-6 microns. Conidial layer dirty-yellowish, becoming darker. Conidia very small, obovate.

Specimens examined:

Brown Co.: on beech, no date, *Owens* (IU).

Monroe Co.: on white walnut, University Dam, Feb. 4, 1911, *Owens* (IU); on walnut, Bloomington, Nov. 25, 1910, *Owens* (IU); on beech, Unionville, Nov. 7, 1910, *Owens* (IU); on black walnut, Bloomington, Nov. 25, 1910, *Owens* (IU); on hickory E. Bloomington, March 4, 1911, *Owens* (IU); on beech, Nov. 12, 1910, *Owens* (IU).

Montgomery Co.: on dead wood, Pine Hills, Sept. 1, 1940, *Simmons 1236* (DPU).

Parke Co.: on old log, Turkey Run State Park, Oct. 27, 1945, *T. G. Yuncker 11921* (DPU); on dead wood, Turkey Run State Park, Oct. 26, 1940, *L. Lee* (DPU); on decaying wood, Fallen Rock, Oct. 16, 1941, *Simmons 1216* (DPU).

Putnam Co.: on rotting limb of *Salix sp.*, DePauw Arboretum, Oct. 10, 1941, *Simmons 1231* (DPU); on rotting stump, field S. W. Blackstock Stadium, Greencastle, Oct. 10, 1941, *Simmons 1232* (DPU);on dead, rotting stump, DePauw Arboretum, Nov. 13, 1941, *Simmons 1233* (DPU); on dead wood, in ravine, DePauw Arboretum, Sept. 12, 1941, *Simmons 1234* (DPU); on rotting log, DePauw Arboretum, Oct. 25, 1945, *Simmons 1228* (DPU); on beech bark, Fern, Oct. 12, 1945, *Simmons 1227* (DPU); on fallen log of *Ulmus sp.*, Fern, Oct. 12, 1945, *Simmons 1239* (DPU); on rotting log, DePauw Arboretum, Sept. 12, 1941, *Simmons 1198* (DPU); on rotting, decorticated wood, DePauw Arboretum, Oct. 25, 1945, *Simmons 1246* (DPU).

Stromata of *H. multiforme* Fr. vary from small, elliptical, depressed-pulvinate patches to broadly effused forms. The globose, distinctly projecting perithecia of this species readily are contrasted to the oblong, densely crowded perithecia of *H. investiens* (Schw.) Berk.

Until comparatively recent times *Hypoxylon atropurpureum* Fries has been considered a distinct species. C. L. Shear, after examination of authentic specimens of Fries, states that "this is only an effuse condition of *multiforme*, it having all the other stromatic and spore characters."[8] *H. atropurpureum* Fr. and *H. multiforme* Fr. are considered as synonyms in the present study.

14. *Hypoxylon perforatum* (Schweinitz) Saccardo

Sphaeria perforata Schweinitz, Syn. fung. Car. 5. 1822.

Hypoxylon perforatum (Schweinitz) Saccardo, Syll. fung. 1:375. 1882.

Stromata superficial, effused or tubercular-convex, often interruptedly confluent for several centimeters, dark or purplish rust-color, dotted with minute, white-margined, punctiform ostiola. Perithecia submonostichous, globose, small (0.25-0.35 mm. in diameter), lying near the surface of the stroma, crowded, mostly not distinctly prominent. Asci cylindrical, sp. p. 60-90 x 7-9 microns, with the ends mostly obtuse, nearly straight or subinequilateral, dark brown, 10-14 x 5-7 microns. Conidial layer cinereous-white, pulveraceous. Conidia minute, ovoid or subglobose on short, simple or branching hyphae.

Specimens examined:

Clark Co.: on *Ostrya sp.*, Borden, Nov. 2, 1908, *J. M. Van Hook 2443* (IU).

Monroe Co.: on *Sassafras sp.*, Unionville, Nov. 12, 1910, *Owens* (IU); on *Juglans nigra*, Bloomington, Jan. 17, 1914, *Ramsey* (IU); on elm, Unionville, Nov. 12, 1910, *Owens* (IU); on sumach, Bloomington, Nov. 25, 1910, *Owens* (IU); on ash, Bloomington, Jan. 28, 1911, *Owens* (IU).

Montgomery Co.: on dead wood, Crawfords' Woods, near Crawfordsville, Oct. 16, 1940, *L. Lee* (DPU).

Morgan Co.: on dead, decorticated wood, ravine near Martinsville, Sept. 20, 1941, *Simmons 1230* (DPU).

Owen Co.: on dead wood of *Ulmus sp.*, McCormick State Park, December 1930, *J. M. Van Hook 5371* (IU).

Putnam Co.: on dead, decaying, decorticated wood, DePauw Arboretum, *Simmons 1213* (DPU); on dead, decaying branch, E. Bainbridge, Nov. 14, 1945, *Simmons 1215* (DPU); on trunk of ironwood, DePauw Arboretum, Nov. 18, 1941, *Simmons 1220* (DPU); on dead, decaying limbs, DePauw Arboretum, Oct. 25, 1945, *Simmons 1221* (DPU); on decorticated wood of beech stump, DePauw Arboretum, Nov. 18, 1941, *Simmons 1222* (DPU); on decorticated wood of dead branch, DePauw Arboretum, Nov. 13, 1941, *Simmons 1238* (DPU); on decorticated wood of fallen limb, DePauw Arboretum, Nov. 13, 1941, *Simmons 1223* (DPU).

[8] Cornelius L. Shear, *Mycologia*, **20**:85-86. 1928.

The minute, white-margined ostiola dotting the dark or purplish rust-colored stromata of this species are a unique and striking characteristic. *H. perforatum* (Schw.) Sacc. rarely would be confused with any other Indiana species of Hypoxylon.

15. *Hypoxylon Petersii* Berkeley & Curtis

Hypoxylon Petersii Berkeley & Curtis, Journ. Linn. Soc. 10:384. 1869.

Stromata pulvinate, depressed-conical, centrally attached with a spreading margin, 3-4 x 2.5-3 cm. across, covered at first by a thick coriaceo-membranaceous veil which soon disappears except around the margin; substance corky-fibrous, hard, dull, umber-colored, becoming darker outside. Perithecia crowded in several layers, subglobose or subelongated, 0.5-0.75 mm. in diameter, with slender necks ending in distinctly prominent, papilliform ostiola. Asci cylindrical, about 60 microns long, sp. p. 40 x 5 microns. Ascospores uniseriate or subbiseriate above, narrowly elliptical, brown, 6-8 x 3.5-4 microns.

Specimens examined:

Monroe Co. (?): on oak, "Huckleberry Ravine," Aug. 7, 1908, *J. M. Van Hook 2147* (IU).

H. Petersii Berk. & Curt., in its gross apsect, is distinguished by its large, irregular, fibrous stromata which bear perithecia crowded in several layers. Among the Indiana species it is unique in its twisted and ridged stromatic tissue.

16. *Hypoxylon rubiginosum* (Persoon) Fries

Sphaeria rubiginosa Persoon, Syn. meth. fung. 11. 1801.

Sphaeria fuscopurpurea Schweinitz, Syn. fung. N. Am. 192. 1831.

Hypoxylon rubiginosum (Persoon) Fries, Summa Veg. Scand. 384. 1849.

Hypoxylon fuscopurpureum (Schweinitz) Berkeley, Journ. Linn. Soc. 10:385. 1869.

Stromata pulvinate or effused, indefinite in extent, quite variable under different environmental conditions. Young stromata variable in color from bright brick-red to purplish-red to reddish-brown. Black in old age. Ectostroma always colored in interior; entostroma always dark. Entostroma may be highly developed (in thick bark) or nearly lacking. Ostiolar necks umbilicate; those of old stromata often stuffed with white mycelial growth from germinating ascospores. Asci 135-160 microns long, sp. p. 70-80 microns long. Stalks long and filiform. Ascospores 9-12 x 4-6 microns.

Specimens examined:

Brown Co.: April 26, 1935, *Witmer* (IU), originally determined as *H. fuscopurpureum* (Schw.) Berk.

Clark Co.: on tulip tree, Borden, Nov. 2, 1908, *J. M. Van Hook 2424* (IU).

Monroe Co.: on elm, Bloomington, *Owens* (IU); on Liriodendron, Bloomington, Fall 1908, *Peck* (IU), originally determined as *H. fuscopurpureum* (Schw.) Berk.

Montgomery Co.: on decorticated log, Crawfords' Wood, near Crawfordsville, Aug. 27, 1917, *Fink & Fuson 288* (MU); on old log, in exposed field, Crawfordsville, Aug. 24, 1917, *Bruce Fink 179* (MU); Pine Hills, Fall 1942, *J. Crowder* (WAB); on dead wood, Crawfordsville, Aug. 4, 1940, *L. Lee* (DPU).

Putnam Co.: Greencastle, April 22, 1908, *Daisy G. Lewis* (DPU); on rotting, decorticated wood, Fern, Oct. 12, 1945, *Simmons 1240* (DPU); on rotting, decorticated log, E. Bainbridge, Nov. 14, 1945, *Simmons 1235* (DPU); on decaying, decorticated limb, W. Greencastle, Nov. 5, 1945, *Simmons 1209* (DPU).

The general stromatic configuration of this species is similar to that of *H. perforatum* (Schw.) Sacc. However, the ostiolar margins of *H. rubiginosum* (Pers.) Fr. do not differ in color from other stromatic material while those of *H. perforatum* are distinctly white against an otherwise rusty purple stroma. *Hypoxylon fuscopurpureum* (Schw.) Berk. now is considered to be merely a purple-red form of *H. rubiginosum*. This relationship is pointed out by J. H. Miller in a discussion on the variability of stromatic form of *H. rubiginosum* under various environmental conditions.[9]

17. *Hypoxylon Sassafras* (Schweinitz) Berkeley

Sphaeria Sassafras Schweinitz, Syn. fung. Car. 10. 1822.
Hypoxylon Sassafras (Schweinitz) Berkeley, Grevillea, 4:54. 1875.

Stromata thin, dirty brownish-black outside, rusty-yellow inside. Perithecia large (1.5 mm. in diameter), the internal cavity nearly 1 mm. in diameter, occuring either singly and quite evenly scattered over the surface of the matrix or loosely aggregated in clusters or groups of 3-8 perithecia standing side by side, their bases united in the thin stroma, with one-third to one-half their upper part free, subtruncate above, with minute, papilliform ostiola. Asci, including the slender base, 110-120 x 4 microns. Ascospores uniseriate, oblong, pale brown, 7-9 x 3 microns. Paraphyses filiform, abundant.

Specimens examined:

Monroe Co.: on *Sassafras sp.*, Bloomington, Feb. 11, 1911, *Owens* (IU).

Specimens of *H. Sassafras* (Schw.) Berk. often are very similar to those of *H. cohaerens* (Pers.) Fr. The perithecia of *H. Sassafras* typically are scattered or loosely aggregated while those of *H.*

[9] Julian H. Miller, *Mycologia*, **20**:315. 1928.

cohaerens are clustered in distinctly hemispherical or subglobose stromata.

18. *Hypoxylon serpens* (Persoon) Fries

Sphaeria Macula Tode, Fungi Meckl. 2:33. 1791.

Sphaeria serpens Persoon, Syn. meth. fung. 20. 1801.

Sphaeria caries Schweinitz, Syn. fung. N. Am. 194. 1831.

Hypoxylon serpens (Persoon) Fries, Summa Veg. Scand. 284. 1849.

Hypoxylon caries (Schweinitz) Saccardo, Syll. fung. 1:393. 1882.

Stromata effused, thin, applanate, black, variable in form and size, often in narrow, elongated strips 2-3 mm. wide and 3-6 cm. long but also in small subelliptical or irregularly shaped patches 1-2 cm. long by 0.5-1 cm. wide. Perithecia subglobose, crowded, rather large, rounded and prominent above or rarely slightly depressed around the central papilla, then only slightly prominent and the surface of the stroma not so distinctly roughened. Asci cylindrical, long-pedicillate, sp. p. 75-100 x 6-8 microns, with aundant paraphyses. Ascospores obliquely uniseriate, subcylindrical, rounded at the ends, oblong-cylindrical, subinequilateral or almost curved, seldom straight, becoming dark, 12-16 x 5-6 microns.

Specimens examined:

Hamilton Co.: on red oak, Jolietville, Dec. 20, 1913, *Ramsey* (IU).

Monroe Co.: on decaying elm, Bloomington, May 11, 1935, *Witmer* (IU).

Montgomery Co.: on *Ulmus sp.* (drift wood), April 1929, *A. R. Bechtel* (IU); on drift wood, Sugar Creek Dam, Crawfordsville, Spring 1929, *A. R. Bechtel 831* (WAB); on dead, rotting wood, Lybyar farm, 10 miles S. W. Crawfordsville, Nov. 22, 1941, *Simmons 1243* (DPU).

Parke Co.: on dead wood, Turkey Run State Park, Nov. 20, 1940, *L. Lee* (DPU).

Putnam Co.: on elm, May 28, 1908, *Daisy G. Lewis* (DPU), originally determined as *H. caries* (Schw.) Sacc.; on decaying decorticated wood, W. Greencastle, Nov. 6, 1945, *Simmons 1225* (DPU).

H. serpens (Pers.) Fr. can best be separated from similar species (*H. insidens* (Schw.) E. & E. and *H. epirrhodium* Berk & Rav.) by comparison of ascospore measurements. Of these three species *H. serpens* produces the largest ascospores (12-16 x 5-6 microns). Study of the type specimens of *H. serpens* and of *H. caries* (Schw.) Sacc. has led Shear to publish the two names in synonymy.[10] He bases this conclusion upon comparison of spore measurements and of substratum conditions. The present study follows Shear's treatment of these species.

[10] Cornelius L. Shear, *Mycologia*, **20**:87. 1928.

19. *Hypoxylon stigmateum* Cooke

Hypoxylon stigmateum Cooke, Grevillea, 7:4. 1879.

Stromata effused, black, crustaceous, thin (0.5-1 mm.), papillose from the prominent ostiola, 3-5 or more centimeters broad, originating beneath the cuticle of the bark which it throws off. Asci linear-cylindrical. Ascospores uniseriate, elliptical, with the ends subacute, sometimes navicular, dark, 20-28 x 8-12 microns.

Specimens examined:

Montgomery Co.: on stump, in woods, July 22, 1917, *Sylvia Fuson 112* (MU); on dead wood, at the Shades, Sept. 6, 1913, *P. J. Anderson* (MU).

Putnam Co.: on dead limb, near Fern, April 17, 1908, *Daisy G. Lewis* (DPU).

Union Co.: on old log, Sayres' Wood, July 25, 1917, *Bruce Fink 78* (MU).

H. stigmateum Cooke and effused forms of *H. multiforme* Fr. have a close macroscopic resemblance because of their black stromata and papillate ostiola. Ascospore measurements are helpful in making a distinction between the two species, the spores of *H. stigmateum* being distinctly larger (20-28 x 8-12 microns) than those of *H. multiforme* (9-14 x 3.5-6 microns).

NUMMULARIA Tulasne

Nummularia Tulasne, Sel. fung. carp. 2:42. 1863.

Stromata orbicular, cup-shaped or discoid, becoming black, marginate, the margin more or less distinctly sterile. Perithecia monostichous, peripherical, immersed. Asci cylindrical, 8-spored. Ascospores uniseriate, subelliptical, continuous, dark.

KEY TO THE SPECIES

1. Stroma cup-shaped with perithecia opening on the concave side 2
   Stroma convex or plane 3
2. Ostiola punctiform, scarcely visible in mature specimens; ascospores globose or subglobose ..... 2. *N. discreta*
   Ostiola projecting, mammillose; ascospores subinequilateral ..... 4. *N. repanda*
3. Ascospores 10-20 microns long 4
   Ascospores 4.5-5 microns long ..... 3. *N. microplaca*
4. Stroma shiny black; adjacent wood stained bright orange ..... 5. *N. tinctor*
   Stroma dull black; wood not stained ..... 1. *N. Bulliardi*

1. *Nummularia Bulliardi* Tulasne

Hypoxylon nummularium Bulliard, Champ. Franc. 1:179. 1791.

Sphaeria nummularia DeCandolle, Flore Franc. 2:290. 1805.

Sphaeria anthracina Schmidt, in Kunze & Schmidt, Mykol. Hefte, 1:55. 1817.

Sphaeria nummularia (Bulliard) Fries, Syst. Mycol. 2:348. 1823.

Nummularia Bulliardi Tulasne, Sel. fung. carp. 2:43. 1863.

Nummularia nummularia (Bulliard) Schroeter, Pilz. Schles. 2:458. 1897.

Nummularia anthracina (Schmidt) Traverso, Fl. Ital. Crypt. Pyr. 1:57. 1906.

Kommamyce Bulliardi (Tulasne) Nieuwland, Am. Mid. Nat. 4:375. 1916.

Numulariola nummularia (Bulliard) House, N. Y. St. Mus. Bull. 266:49. 1925.

Stromata convex, orbicular or oval, sometimes irregular in shape or broadly effused, black inside and out, punctate from the slightly prominent ostiola, at first covered by the epidermis and clothed with a reddish layer of conidia, soon erumpent, almost superficial and free. Perithecia large, ovate, black, loosely included in the packed cells of the stroma. Asci cylindrical with very short stalks, sp. p. 115-140 x 7-10 microns. Paraphyses long and stout. Ascospores eight, uniseriate, elliptical, hyaline, becoming opaque or brown, 10-20 x 5-10 microns.

Specimens examined:

Hendricks Co.: on old log, open pasture, Aug. 10, 1917, *Fuson 129* (MU).

Monroe Co.: on *Acer sp.*, Unionville, Nov. 7, 1910, *Owens* (IU); on beech, N. E. Bloomington, March 20, 1931, *Amidei & Marten* (IU); on dogwood, 1916, *J. M. Van Hook 3708* (IU); Unionville, Oct. 21, 1911, *Owens* (IU); on *Fagus sp.*, Bloomington, March 4, 1911, *Owens* (IU); on beech, Unionville, Oct. 21, 1911, *Owens* (IU); on beech, Unionville, Nov. 7, 1910, *Owens* (IU).

Montgomery Co.: on trunk of dead, fallen tree, ravine in Shades Park, Nov. 9, 1941 *Simmons 1166* (DPU); on beech log, woods on Lybyar farm, S. W. Crawfordsville, Nov. 22, 1941, *Simmons 1168* (DPU).

Parke Co.: on dead wood, Turkey Run State Park, Nov. 22, 1940, *L. Lee* (DPU); on bark of dead oak stump, Fallen Rock, Oct. 16, 1941, *Simmons 1173* (DPU).

Putnam Co.: on dead beech log, Greencastle, Jan. 22, 1908, *Daisy G. Lewis* (DPU); on dead beech log, Greencastle, May 27, 1908, *Daisy G. Lewis* (DPU); on small fallen trunk, Fern, Oct. 12, 1945, *Simmons 1161* (DPU); on decaying, fallen branch, Fern, Oct. 12, 1945, *Simmons 1162* (DPU); on fallen beech limb, DePauw Arboretum, Oct. 10, 1941, *Simmons 1164* (DPU); on fallen beech log, valley E. Bainbridge, Oct. 17, 1941, *Simmons 1170* (DPU); on rotting oak limb, valley E. Bainbridge, Oct. 17,

1941, *Simmons 1171* (DPU); on dead, decaying limb, W. Greencastle, Nov. 6, 1945, *Simmons 1172* (DPU); on beech log, 3 mi. W. Greencastle, May 14, 1946, *Winona H. Welch 9017* (DPU).

N. Bulliardi Tul. is common in Indiana on the trunks and branches of various deciduous trees. Its stromata often closely resemble those of *N. microplaca* (Berk. & Curt.) Cke. and of *N. tinctor* (Berk.) E. & E., but its ascospores (12-20 microns long) are much longer than those of *N. microplaca* (4.5-5 microns long) and its stromata do not stain the substratum as do those of *N. tinctor*.

2. *Nummularia discreta* (Schweinitz) Tulasne

Sphaeria discincola Schweinitz, Syn. fung. Car. 8. 1822.

Sphaeria discreta Schweinitz, Syn. fung. N. Am. 195. 1831.

Sphaeria excavata Schweinitz, Syn. fung. N. Am. 195. 1831.

Nummularia discreta (Schweinitz) Tulasne, Sel. fung. carp. 2:45. 1863.

Stromata erumpent, concave, with a thick raised margin, circular, definite in outline, 3-5 mm. in diameter, gray or yellow-gray, becoming black; the concave side at first white-punctate from the minute ostiola which are scarcely visible when mature. Bark and wood beneath the stromata marked by black, circumscribing lines. Perithecia monostichous, oval or ovate-cylindrical, about 1 mm. long, contracted above into ostiolar necks varying in length, extending to the base of the stroma. Asci cylindrical, short-stalked, 140-200 x 12-15 microns. Paraphyses long, filiform. Ascospores globose, black at maturity, 10-14 microns in diameter, uniseriate in the ascus. Conidia continuous and hyaline, borne above the ectostroma.

Specimens examined:

Monroe Co.: on *Amelanchier sp.*, near Bloomington, April 15, 1911, *J. M. Van Hook 3187* (IU).

County unrecorded: on dead limb of apple, May 9, 1901, *A. G. Wood* (IU).

N. discreta (Schw.) Tul. and *N. repanda* (Fr.) Nke. are very similar Indiana species. The punctiform ostiola of *N. discreta*, however, are scarcely visible in mature specimens while ostiola of *N. repanda* are distinctly prominent giving the surface of the stroma a mammillose appearance.

3. *Nummularia microplaca* (Berkeley & Curtis) Cooke

Diatrype microplaca Berkeley & Curtis, Journ. Linn. Soc. 10:385. 1869.

Anthostoma microplacum Saccardo, Syll. fung. 1:298. 1882.

Nummularia microplaca (Berkeley & Curtis) Cooke, Grevillea, 12:8. 1883.

Stromata orbicular to subelliptical, 0.5-1 cm. across, or elongated 1-4 x 0.5-1 cm., or extending by confluence for long distances in the

grooves of the bark, forming a thin carbonaceous crust, black, arising beneath the epidermis but soon becoming bare, surface even, faintly punctate from the minute ostiola. Perithecia ovate-globose, small (less than 0.5 mm. across), monostichous. Ostiola minute, not prominent but slightly depressed, the opening at first filled with a white farinaceous matter. Asci 60-80 x 3-5 microns, sp. p. 40-50 microns long. Ascospores uniseriate, ends mostly slightly overlapping, elliptical, inequilateral, pale brown, 5-7.5 x 2.5-3 microns.

Specimens examined:

Monroe Co.: on *Sassafras sp.*, Bloomington, March 4, 1911, *Owens* (IU); on *Sassafras sp.*, W. Bloomington, May 18, 1935, *Witmer* (IU).

Superficially similar to this species are *N. Bulliardi* Tul. and *N. tinctor* (Berk.) E. & E. However, the ascospores of *N. microplaca* are very short (4.5-5 microns long) in comparison with those of the other two species (10-20 microns long).

4. *Nummularia repanda* (Fries) Nitschke

Sphaeria repanda Fries, Syst. Mycol. 2:346. 1823.

Hypoxylon repandum Fries, Summa Veg. Scand. 383. 1849.

Nummularia repanda (Fries) Nitschke, Pyr. Germ. 57. 1867.

Nummularia pezizoides Ellis & Everhart, Bull. Torr. Bot. Club, 11:74. 1884.

Stromata erumpent-superficial, orbicular or subelliptical, 0.5-1 cm. in diameter, concave and often with a thin, erect, rather broad margin, reddish-gray at first, finally black, mammillose from the projecting ostiola. Perithecia monostichous, immersed, ovate-oblong, 0.5-0.75 mm. long, crowded, often subangular from mutual pressure. Asci cylindrical, subsessile, 8-spored, 110-120 x 8 microns. Ascospores obliquely uniseriate, narrow ovate, obtuse, subinequilateral, dark brown, 8.5-14 x 4-7.5 microns.

Specimens examined:

Clark Co.: on decorticated hickory, Borden, Nov. 2, 1908, *J. M. Van Hook 2420* (IU).

Monroe Co.: on elm, near Bloomington, Nov. 25, 1910, *Owens* (IU).

Putnam Co.: on dry dead branch, DePauw Arboretum, Oct. 25, 1945, *Simmons 1174* (DPU).

The stromatic disk of *N. repanda* (Fr.) Nke. is mammillose-roughened due to the prominent ostiola; the disk of *N. discreta* (Schw.) Tul., in contrast, is comparatively smooth, the minute ostiola being scarcely visible in mature specimens.

5. *Nummularia tinctor* (Berkeley) Ellis & Everhart

Sphaeria tinctor Berkeley, Hook. London Journ. Bot. 4:311. 1845.

Hypoxylon tinctor (Berkeley) Cooke, Grevillea, 13:16. 1884.

Nummularia tinctor (Berkeley) Ellis & Everhart, N. Am. Pyr. 627. 1892.

Stromata much effused showing irregularities of surface upon which it grows, very hard and brittle, 1 mm. thick, black, with surface almost smooth but distinctly papillose from projecting ostiola (as seen under the handlens); wood beneath the stromata stained definitely reddish-orange and rendered very hard. Perithecia monostichous, crowded, elongate (0.75 mm. long), covered above with the ectostromatic layer. Asci 100-140 x 6-10 microns, sp. p. 75-120 microns long. Paraphyses filiform, abundant. Ascospores uniseriate, pale brown, conspicuously uniguttulate, oblong navicular, 13-20 x 5-8 microns.

Specimens examined:

Monroe Co.: on *Acer sp.*, E. Bloomington, Oct. 13, 1911, *Owens* (IU).

Montgomery Co.: on bark of fallen limb, in ravine, Shades Park, Nov. 9, 1941, *Simmons 1165* (DPU).

Orange Co.: on sycamore, Paoli, March 25, 1910, *Owens* (IU).

Owen Co.: on *Acer sp.*, State Park, Dec. 11, 1934, *Martens* (IU).

Parke Co.: on bark, Turkey Run State Park, Nov. 22, 1940, *L. Lee* (DPU).

Putnam Co.: on living limb of *Betula sp.*, Theta lawn, Greencastle, Nov. 14, 1945, *Simmons 1157* (DPU); on dead limb of *Quercus sp.*, E. Bainbridge, Nov. 14, 1945, *Simmons 1158* (DPU); on dead, decaying limb, E. Bainbridge, Nov. 14, 1945, *Simmons 1159* (DPU).

N. tinctor (Berk.) E. & E. is distinct among the Indiana species of the genus by reason of the bright red-orange color it imparts to its substratum. The coloring of the wood by the fungus is accompanied by hardening of the substratum tissues immediately adjacent to the stroma.

ROSELLINIA Cesati & DeNotaris

Rosellinia Cesati & DeNotaris, Giorn. Bot. Ital. 2:334. 1847.

Pleosporopsis Oersted, Nat. For. Vid. Medd. 128. 1865.

Stromatic layer thin, each mature perithecium being tightly enclosed within an ectostromatic layer. Perithecia nearly superficial, globose, papillate, subcarbonaceous, black, smooth to rough, often associated with a subiculum. Asci cylindrical-clavate, paraphysate, 8-spored. Ascospores globose-ovoid to navicular, dark, ends obtuse to appendiculate.

KEY TO THE SPECIES

1. Perithecia small (0.33-0.5 mm. in diameter) 2
   Perithecia large (0.75-1.5 mm. in diameter) 3
2. Perithecia gregarious, not bristly ..... 7. *R. pulveracea*
   Perithecia usually scattered, bristly ..... 3. *R. ligniaria*
3. Subiculum usually prominent 4
   Subiculum scanty 6
   Subiculum wanting 7
4. Subiculum brown or purplish-brown, persistent 5
   Subiculum sulphur-yellow, evanescent ..... 8. *R. subiculata*
5. Ectostromatic tissue thick, carbonaceous; asci (sp. p.) more than 130 microns long ..... 1. *R. aquila*
   Ectostromatic tissue thin, very brittle; asci (sp. p.) less than 130 microns long ..... 9. *R. thelena*
6. Subiculum dark brown; asci 7-8 microns wide ..... 5. *R. medullaris*
   Subiculum black; asci 8-10 microns wide ..... 4. *R. mammiformis*
7. Bases of perithecia glandular-roughened ..... 2. *R. glandiformis*
   Bases of perithecia not glandular-roughened 8
8. Asci (sp. p.) less than 95 microns long ..... 6. *R. mutans*
   Asci (sp. p.) more than 95 microns long 9
9. Ectostroma sooty, powdered-roughened ..... 5. *R. medullaris*
   Ectostroma bare ..... 4. *R. mammiformis*

1. *Rosellinia aquilla* (Fries) Cesati & DeNotaris

Sphaeria byssiseda Tode, Fungi Meckl. 2:10. 1791.

Sphaeria papillosa Sowerby, Engl. Fungi, Vol. 2, pl. 236. 1799.

Sphaeria aquila Fries, Vet. Akad. Hand. 1817:251. 1817.

Sphaeria aquila Fries, Syst. Mycol. 2:442. 1823.

Sphaeria mammosa Withering, Bot. Arr. 4:360. 1830.

Rosellinia aquila (Fries) Cesati & DeNotaris, Schema Sfer. Ital. 21, 1863.

Hypoxylon aquila (Fries) Brefeld, Unters. Gesammt. Mykol. 10:259. 1891.

Rosellinia byssiseda (Tode) Schroeter, Krypt.-Flora Schles. 3:299. 1894.

Subiculum rather thick and prominent, dark to purplish-brown, nearly enveloping the perithecia at first but finally more or less disappearing. Perithecia large, globose, 1-1.25 mm. in diameter, gregarious, crowded or sometimes confluent, with distinct, black, conic-papilliform ostiola, dark brown at first with a thin tomentose coating, finally becoming bare. Ectostroma thick, carbonaceous. Perithecial wall coriaceous. Asci long, cylindrical, sp. p. 165-190 x 10-12.5 microns. Ascospores uniseriate, oblong, brown, 16-27.5 x 8-11 microns, with or without a short, obtuse, hyaline appendage 2-2.5 microns long at each end.

Specimens examined:

Clark Co.: on chestnut, Borden, Nov. 2, 1908, *J. M. Van Hook 2417* (IU).

Monroe Co.: on *Juglans sp.*, E. Bloomington, March 22, 1931, *Martens* (IU); on oak, Unionville, Nov. 12, 1911, *Ramsey* (IU).

Montgomery Co.: April 1929, *A. R. Bechtel* (IU); Turners' Woods, near Crawfordsville, May 21, 1941, *Simmons 1104* (DPU).

Owens Co.: on *Prunus sp.*, McCormick's Creek State Park, June 1938, *Banta* (IU).

Putnam Co.: on dead beech log, Greencastle, Jan. 22, 1908, *Daisy G. Lewis* (DPU); on dead limbs in brush pile, DePauw Arboretum, Oct. 25, 1945, *Simmons 1226* (DPU).

Of the Indiana species of Rosselinia *R. thelena* (Fr.) Rab. is most nearly similar to *R. aquila* (Fr.) Ces. & DeNot. The ectostroma of *R. aquila*, however, is carbonaceous and relatively thick in contrast to the very brittle, thin ectostromatic layer of *R. thelena*.

2. *Rosellinia glandiformis* Ellis & Everhart

Rosellinia glandiformis Ellis & Everhart, Proc. Acad. Nat. Sci. Phil. 42:227. 1890.

Perithecia scattered, the bases sunken in the wood about one-fourth, ovate-globose, roughened with glands, with reinforcement around the lower half similar to the cupule of an acorn (this thickening sometimes reduced to a thin granular coat). Ostiola papilliform, small, sometimes obsolete, the apices of the perithecia then being evenly rounded. Asci cylindrical, 100-114 x 8-10 microns. Paraphyses abundant. Ascospores uniseriate, acutely elliptical, opaque, 14-17.5 x 7-10 microns.

Specimens examined:

Monroe Co.: on poplar, Bloomington, 1908, *J. M. Van Hook 3550* (IU); on *Juglans sp.*, Bloomington, Nov. 20, 1913, *Ramsey* (IU); on *Fraxinus sp.*, Bloomington, Jan. 17, 1914, *Ramsey* (IU).

Putnam Co.: on well-rotted, decorticated wood, E. Bainbridge, Nov. 14, 1945, *Simmons 1194* (DPU).

The bases of the perithecia of *R. glandiformis* E. & E. characteristically are glandular-roughened in contrast to the relatively smooth perithecia of the otherwise macroscopically similar *R. mutans* (Cke. & Pk.) Sacc. The subiculum present in many species of Rosellinia is noticeably lacking in specimens of *R. glandiformis*.

3. *Rosellinia ligniaria* (Greville) Saccardo

Sphaeria ligniaria Greville, Scot. Crypt. Flora, 1:82. 1823.

Rosellinia ligniaria (Greville) Saccardo, Syll. fung. 1:269. 1882.

Perithecia scattered, gregarious or crowded, sometimes forming a crust, ovate-conical, very black, superficial, about 0.25 mm. in

diameter, clothed with minute black bristles about 20-30 microns long. Asci cylindrical, sp. p. 65-75 x 8-10 microns. Ascospores obliquely uniseriate, elliptical, brown, 10-14 x 6-8 microns.

Specimens examined:

Hamilton Co.: on *Fraxinus sp.*, Jolietville, March 28, 1914, *Ramsey* (IU).

Putnam Co.: on rotting wood, in ravine, DePauw Arboretum, Oct. 12, 1941, *Simmons 1183* (DPU); on rotting wood, E. Bainbridge, Nov. 14, 1945, *Simmons 1186* (DPU); on dead, decorticated *Populus nigra* var. *Italica*, Greencastle, Nov. 1, 1945, *Simmons 1195* (DPU).

R. ligniaria (Grev.) Sacc., like *R. pulveracea* (Ehrenb.) Fkl., produces very small (0.33-0.5 mm. in diameter) perithecia. The perithecia of *R. ligniaria* usually are well-separated on the substratum and are covered with minute black bristles; those of *R. pulveracea* are gregarious to almost confluent and typically bare.

4. *Rosellinia mammiformis* (Persoon) Saccardo

Sphaeria mammiformis Persoon, Syn. meth. fung. 64. 1801.

Hypoxylon globulare (Bulliard) Fuckel, Fung. Rehn. No. 1060, (*fide* Ellis & Everhart, N. Am. Pyr. 166. 1892). 1866.

Hypoxylon mammaeforme Berkeley, Grevillea, 4:52. 1875.

Rosellinia mammiformis (Persoon) Saccardo, Syll. fung. 1:258. 1882.

Perithecia gregarious, crowded or confluent, (2-3 in one stroma), globose, 1-1.5 mm. in diameter, fragile, black and bare but not polished. Ostiola abruptly papilliform, black and subshining. Asci (sp. p.) 100-115 x 8-10 microns. Paraphyses abundant. Ascospores 19-25 x 7-12 microns, oblong, elliptical, sometimes slightly curved, mostly without any distinct appendage.

Specimens examined:

Monroe Co.: Unionville, Oct. 21, 1913, *Peck* (IU).

The scanty black subiculum produced by *R. mammiformis* (Pers.) Sacc. usually is absent in mature specimens. Ascus measurements and the bareness of the surface of the ectostroma of this species serve to distinguish it from *R. medullaris* (Wallr.) Ces. & DeN. whose asci are comparatively narrow (asci of *R. medullaris* 7-8 microns wide; *R. mammiformis* 8-10 microns wide) and whose ectostroma characteristically is powdered with a fine, sooty covering.

5. *Rosellinia medullaris* (Wallroth) Cesati & DeNotaris

Sphaeria medullaris Wallroth, Fl. Crypt. Germ. 2:792. 1833.

Rosellinia medullaris (Wallroth) Cesati & DeNotaris, Schema Sfer. Ital. 177. 1863.

Rosellinia Macouniana Ellis & Everhart, Bull. Torr. Bot. Club, 11:74. 1884.

Perithecia gregarious or crowded, superficial, globose or ovate-globose, 0.75-1.5 mm. in diameter, covered at first with a pruinose-pubescent coat of a dull red or brick-red color, becoming bare and black with age, loosely adnate, apices convex to conic-papilliform, surface dirty-roughened with a finely powdered, sooty covering, very fragile, subiculum slight or lacking. Asci (sp. p.) 100-120 x 7-8 microns. Ascospores 19-25 x 6-7 microns, uniseriate, ovoid, only slightly curved, sometimes obscurely appendiculate, brown.

Specimens examined:

Monroe Co.: Bloomington, 1914, *Ramsey* (IU).

This species is very similar to *R. mammiformis* (Pers.) Sacc. but may be distinguished by the sooty roughness of the ectostroma surface and by its comparatively narrow asci.

6. *Rosellinia mutans* (Cooke & Peck) Saccardo

Sphaeria mutans Cooke & Peck, 29th Rep. N. Y. St. Mus. 64. 1876.

Rosellinia mutans (Cooke & Peck) Saccardo, Syll. fung. 1:259. 1882.

Perithecia more or less crowded or gregarious, rather small, about 0.5-0.75 mm. in diameter, at first clothed with a thin, tawny, evanescent tomentum, finally becoming smooth, black, and shining, mostly globose with papillate ostiola. (Region about ostiolum may have tendency to be depressed.) Asci subcylindrical, sp. p. 80-92.5 x 6.5-7.5 microns. Ascospores uniseriate, elliptical, brown, 9-13 x 4-5.5 microns.

Specimens examined:

Monroe Co.: on *Juglans sp.*, Bloomington, November 1913, *Ramsey* (IU).

Posey Co.: on decorticated elm, May 12, 1928, *Shaw* (IU).

Warren Co.: Pine Village, April 1940, *Gray* (IU).

R. mutans (Cke. & Pk.) Sacc. is very similar to *R. glandiformis* E. & E. in its perithecial size and lack of a subiculum. Mature stromata of *R. mutans* are black and shining while those of *R. glandiformis* are glandular-roughened.

7. *Rosellinia pulveracea* (Ehrenberg) Fuckel

Sphaeria pulveracea Ehrenberg, in Persoon, Syn. meth. fung. 83. 1801.

Sphaeria millegrana Schweinitz, Syn. fung. N. Am. 213. 1831.

Sphaeria transversalis Schweinitz, Syn. fung. N. Am. 213. 1831.

Sordaria Friesii Niessl, Vorarb. z. Crypt. Fl. von Mähren. 112. 1864.

Rosellinia pulveracea (Ehrenberg) Fuckel, Symb. Mycol. 149. 1869.

Rosellinia Friesii Niessl, Beitr. z. Kentniss d. Pilze. 34. 1872.

Perithecia densely gregarious, often forming a continuous crustaceous layer but sometimes scattered, ovate-globose, minutely tubercular-roughened, about 0.33 mm. in diameter. Ostiola papilliform, soon perforated. Asci cylindrical, 60-70 x 10-12 microns, with a stipitate base 20-30 microns long. Paraphyses filiform. Ascospores uniseriate, elliptical, brown, 8-15 x 6-9 microns.

Specimens examined:

Hamilton Co.: on *Platanus sp.*, Jolietville, Dec. 18, 1913, *Ramsey* (IU).

Monroe Co.: on *Ostrya sp.*, Bloomington, Nov. 20, 1913, *Ramsey* (IU).

Montgomery Co.: Shades Park, March 12, 1941, *Simmons 1122* (DPU).

Putnam Co.: on dead decorticated wood, DePauw Campus, Nov. 13, 1945, *Simmons 1184* (DPU); on dead branch of *Platanus sp.*, E. Bainbridge, Nov. 14, 1945, *Simmons 1185* (DPU).

R. pulveracea (Ehrenberg) Fuckel and *R. ligniaria* (Grev.) Sacc. are alike in their production of very small perithecia (0.35-0.5 mm. in diameter). The perithecia of *R. ligniaria* typically are scattered on the substratum and are covered with short, stiff bristles while those of *R. pulveracea* usually are densely crowded and bare.

8. *Rosellinia subiculata* (Schweinitz) Saccardo

Sphaeria subiculata Schweinitz, Syn. fung. N. Am. 210. 1831.

Hypoxylon subiculosum Berkeley, Grevillea, 4:52. 1875.

Rosellinia subiculata (Schweinitz) Saccardo, Syll. fung. 1:255. 1882.

Perithecia thin-walled, gregarious or crowded but often more or less scattered in the early stages, about 1 mm. in diameter, globose, black and shining, mostly superficial, seated on a sulphur-yellow, waxy-pruinose subiculum which disappears with age. Ostiola small, papilliform. Asci 80-90 x 6-7 microns, cylindrical, with abundant paraphyses. Ascospores uniseriate or partly biseriate above, inequilaterally elliptical, brown, subacute, 10-12.5 x 5-6.5 microns.

Specimens examined:

Clark Co.: on poplar, Borden, 1909, *J. M. Van Hook 2442* (IU).

Monroe Co.: on tulip tree, Unionville, October 1911, *J. M. Van Hook 3554* (IU).

Montgomery Co.: Covington Hill, Crawfordsville, Nov. 12, 1942, *J. Crowder 1611* (WAB).

This species characteristically produces a sulphur-yellow subiculum which, however, disappears with age. The length of its ascospores (10-12.5 microns), when the subiculum is absent, serves to distinguish it from *R. aquila* (Fr.) Ces. & DeN. (16-27.5 microns) and from *R. thelena* (Fr.) Rab. (18-23 microns).

9. *Rosellinia thelena* (Fries) Rabenhorst

Sphaeria thelena Fries, in Schmidt & Kunze, Mykol. Hefte, 2:36. 1823.

Rosellinia thelena (Fries) Rabenhorst, Kryptogamen-Flora, ed. 2, 2:225. 1887.

Perithecia crowded or gregarious, spherical, with strongly papilliform ostiola, smooth, thin, brittle, brownish-black, about 1 mm. in diameter, seated on a superficial, loosely adherent, densely interwoven but thin, brownish-purple subiculum. Asci cylindrical, stipitate, 8-spored, 90-130 x 8-9 microns (sp. p.), with conglutinated paraphyses. Ascospores uniseriate, oblong, subinequilateral, brown, 18-23 x 6-7 microns, with a short (6-8 microns), hyaline, spine-shaped appendage at each end.

Specimens examined:

Parke Co.: on hemlock, Turkey Run, April 27, 1930, *Hughes* (IU).

The habits of growth and the average sizes of the perithecia of *R. thelena* (Fr.) Rab. and of *R. aquila* (Fr.) Ces. & DeN. are about the same. The ectostromatic tissue of *R. thelena*, however, is thin and brittle while that of *R. aquila* typically is thick and carbonaceous in texture.

USTULINA Tulasne

Ustulina Tulasne, Sel. fung. carp. 2:23. 1863.

Stromata superficial, subeffused, thick, determinate, at first carnose-suberose and clothed with a powdery, cinereous, conidial hymenium, finally rigid, carbonaceous, black and bare, generally more or less hollow. Perithecia immersed, large, with papilliform ostiola. Asci pedicillate, 8-spored, paraphysate. Ascospores ovoid-fusiform, continuous, dark-colored.

Ustulina vulgaris Tulasne

Sphaeria deusta Hoffmann, Veg. Crypt. 1:3. 1787.

Sphaeria versipellis Tode, Fungi Meckl. 2:55. 1791.

Hypoxylon ustulatum Bulliard, Hist. Champ. Franc. 1:176. 1791.

Hypoxylon deustum Greville, Scot. Crypt. Flora, Vol. 4, pl. 324. 1826.

Ustulina vulgaris Tulasne, Sel. fung. carp. 2:22. 1863.

Stromata superficial, effused, repand, pulvinate, thick; at first surface even, white and subtomentose, substance almost gelatinous; becoming hard and tough, undulate-colliculose; finally very brittle and hollow, black. Perithecia large, ovate, densely crowded, monostichous, only the punctiform ostiola projecting. Asci narrow cylindrical, pedicillate, 8-spored, sp. p. 250 x 8-10 microns. Paraphyses slender, evanescent. Ascospores obliquely uniseriate, fusoid, inequilateral or slightly curved, finally opaque, 32-40 x 8-10 microns.

Specimens examined:

Brown Co.: on American beech, in brush pile, on earthen dam of Ogle Lake, Brown County State Park, Oct. 21, 1945, *Winona H. Welch 9006* (DPU).

Clark Co.: on fallen elm, Tunnel Mill Reservation, Jeffersonville, April 14, 1933, *R. Dawson* (DPU); on fallen elm tree, Tunnel Mill Reservation, April 14, 1933, *Gray* (DPU); on beech, Borden, Nov. 2, 1908, *J. M. Van Hook 2441* (IU).

Monroe Co.: on old stump, Bloomington, Oct. 17, 1940, *Lohman* (IU); Bloomington, Fall 1907, *J. M. Van Hook 2239* (IU).

Montgomery Co.: on bark of fallen log, Pine Hills, S. Crawfordsville, Sept. 1, 1940, *Simmons 1150* (DPU).

Morgan Co.: on rotting log, ravine N. E. Martinsville, Sept. 20, 1941, *Simmons 1149* (DPU).

Parke Co.: at base of maple, Turkey Run, Aug. 23, 1917, *Fink & Fuson 166* (MU); on dead wood, Turkey Run State Park, Nov. 20, 1940, *L. Lee* (DPU).

Putnam Co.: Greencastle, November 1892, no name (DPU); on old stump near springs, Greencastle, Jan. 22, 1908, *Daisy G. Lewis* (DPU); on decaying log, in ravine, Hoosier Highlands, April 27, 1943, *Winona H. Welch 9005* (DPU); on decaying stump of *Ulmus sp.*, DePauw Campus, Nov. 13, 1945, *Simmons 1153* (DPU); on bark of rotting limb, DePauw Arboretum, Oct. 25, 1945, *Simmons 1154* (DPU); on cork at base of trunk of living *Tilia sp.*, DePauw Arboretum, Oct. 25, 1945, *Simmons 1155* (DPU); on cork at base of trunk of living *Fagus sp.*, DePauw Arbroetum, Oct. 25, 1945, *Simmons 1156* (DPU).

Union Co.: on stump, July 21, 1917, *Fink & Fuson 9* (MU).

Wabash Co.: on elm stump, Roann, March 23, 1908, *Daisy G. Lewis* (DPU).

XYLARIA (Hill) Schrank

Xylaria Hill, Hist. Plant. 62. 1751.

Xylaria (Hill) Schrank, Baierische Flora, 2:566. 1789.

Thamnomyces Ehrenberg, in Nees, Hor. Phys. Berol. 79. 1820.

Xylariodiscus Hennings, Hedwigia, 38:63. 1899.

Moelleroclavus Hennings, Hedwigia, 41:15. 1902.

Stromata erect or ascending, cylindrical, clavate, filiform, often compressed, simple or branched, of a corky, leathery, or fleshy consistence, black outside, mostly white within. Perithecia sunken in the stroma but more or less prominent, globose or ovate, with short necks and papilliform ostiola. Asci cylindrical, 8-spored. Ascospores elliptical or fusoid, continuous, black, mostly inequilateral.

KEY TO THE SPECIES

1. Head fertile throughout 2
   Head with apex sterile 4
2. Stipe bare when mature 3
   Stipe villous when mature ..... 2. *X. corniformis*
3. Ascospores 20-30 microns long ..... 5. *X. polymorpha*
   Ascospores 7-8-(15) microns long ..... 1. *X. castorea*
4. Stipe glabrous 5
   Stipe villous ..... 4. *X. Hypoxylon*
5. Stroma thick, branching ..... 3. *X. digitata*
   Stroma filiform ..... 6. *X. subterranea*

1. *Xylaria castorea* Berkeley

Xylaria castorea Berkeley, Fl. Nov. Zel. 204. 1855.

Stromata simple, solitary, rising from a reddish-brown, spongy, irregularly shaped base 1-2 cm. high; stipes short (less than 2 cm. long); heads subclavate to clavate, somewhat compressed or flattened, 1-4.75 cm. high and 0.5-1 cm. wide, brown to brownish-black, smooth to minutely areolate from depressions in the surface, with a few scattered, protruding ostiola, obtusely rounded at the apex, fertile throughout. Perithecia compact to scattered, generally compressed because of crowded condition, measuring about 0.33-0.75 mm. in diameter. Asci cylindrical, 8-spored, sp. p. 50-80 x 5-7.5 microns with a slender stipe one-third to one-half as long. Ascospores brown, uniseriate, elliptical, slightly inequilateral, 7-15 x 4-7 microns.

Specimens examined:

Hendricks Co.: on log, Aug. 8, 1917, *Sylvia Fuson 130* (MU).

Monroe Co.: on dead stump, Bloomington, Jan. 21, 1902, *Mutchler* (IU).

Putnam Co.: on rotting log, DePauw Arboretum, Oct. 25, 1945, *Simmons 1176* (DPU); on rotting bark, in ravine, DePauw Arboretum, Oct. 10, 1941, *Simmons 1177* (DPU); on decaying stump, ravine S. W. DePauw Arboretum, *Roy Veselinovich* (DPU).

Stromata of *X. castorea* Berk. may resemble the smaller growth forms of *X. polymorpha* (Pers.) Grev. Ascospore measurements of the two species show those of *X. castorea* to average 7-8 microns in length with a maximum of 15 microns while those of *X. polymorpha* are 20-30 microns long.

2. *Xylaria corniformis* Fries

Sphaeria corniformis Fries, Elench. Fung. 2:57. 1828.

Xylaria corniformis Fries, Summa Veg. Scand. 381. 1849.

Stromata usually single and scattered but sometimes two or three are connected at the base, simple, club-shaped, not compressed,

obtuse at the apex, fertile throughout, the heads of the mature specimens divided into small, variously shaped areas (areolate-rimose), brownish-black, rough with papilliform ostiola, 3-6 mm. in diameter, 2.5-5 cm. in height; stipes short, black, villous, arising from a spongy, brownish-purple, tubercular base. Perithecia compact, compressed because of crowded condition, 0.33-0.5 mm. across. Asci cylindrical, somewhat stipitate, 8-spored, sp. p. 45-70 x 5-6 microns. Ascospores obliquely uniseriate, inequilaterally elliptical, rounded at the ends, brown, 7.5-12 x 4-5.5 microns.

Specimens examined:

Monroe Co.: on dead beech, Unionville, Oct. 21, 1911, *Owens* (IU).

Montgomery Co.: *Hensmer* (IU); on old log, in wood near Sugar Creek, near Crawfordsville, Sept. 1, 1917, *Fink & Fuson 393* (MU).

Posey Co.: on oak log in Schuffle Pond, May 13, 1939, *Winona H. Welch 5817* (DPU).

Putnam Co.: Fern, October 1892, *L. M. Underwood* (DPU, IU).

The stipes of many species of Xylaria are bare in mature specimens, but *X. corniformis* Fr. characteristically retains its villous appearance. In contrast to *X. Hypoxylon* (L.) Grev., which also is villous in age, the stromata of *X. corniformis* are fertile throughout while those of *X. Hypoxylon* are sterile at the apices.

3. *Xylaria digitata* (Linnaeus) Greville

Clavaria Hypoxylon Schaeffer, Icon. Fung. Pl. 265. 1761.

Sphaeria clavata Hoffmann, Veg. Crypt. Vol. 1, pl. 4. 1787.

Sphaeria digitata Ehrenberg, Beiträge, 6:7. 1792.

Clavaria digitata Linnaeus, Syst. Veg. ed. 15, 1010. 1798.

Xylaria digitata (Linnaeus) Greville, Flora Edin. 356. 1824.

Hypoxylon digitatum Link, Handbuch, 3:348. 1833.

Stromata erect, tufted, connate below, thick, dark-brown, leprose-velutinous, becoming glabrous, round and simple, gradually attenuated above, rarely obtuse or 2-3 dichotomously divided, rarely more or less compressed or forked, covered at first with the white conidial hymenium. Fertile head occupying the middle of the stroma, attenuated below into a short stipe and ending above in a sterile apex. Perithecia numerous, densely crowded, slightly prominent, with papilliform ostiola. Asci cylindrical, long-pedicillate, 8-spored, sp. p. 100-120 x 7 microns. Ascospores overlapping-uniseriate, navicular-fusoid, subobtuse and slightly curved, dark brown, 12-16 x 5-6 microns.

Specimens examined:

Montgomery Co.: on old wood, Ladoga, Aug. 20, 1910, *H. W. Anderson* (MU).

The apices of the stromata of *X. digitata* (L.) Grev., like those of *X. Hypoxylon* (L.) Grev., are sterile. The stipes of mature specimens of *X. digitata* are glabrous while those of *X. Hypoxylon* are woolly-tomentose.

4. *Xylaria Hypoxylon* (Linnaeus) Greville

Valsa digitata Scopoli, Fl. Carniol. 2:398. 1722.
Clavaria Hypoxylon Linnaeus, Fl. Suec. ed. 2, 457. 1755.
Clavaria hirta Batsch, Elench. Fung. Cont. 1:229. 1786.
Sphaeria cornuta Hoffmann, Veg. Crypt. 1:11. 1787.
Clavaria cornuta Bulliard, Hist. Champ. Franc. 1:193. 1791.
Sphaeria Hypoxylon Persoon, Obs. Mycol. 1:20. 1796.
Sphaeria ramosa Dickson, Plant. Crypt. Brit. 4:27. 1801.
Xylaria Hypoxylon (Linnaeus) Greville, Flora Edin. 355. 1824.
Sphaeria digitata Bolton, Fungi Hal. 3:130. 1891.

Stromata simple to variously branched, cylindric to compressed, black, 0.75-4.5 cm. high, pointed and sterile at the apices; heads larger than stipe, roughened by more or less prominent, ovate, papilliform ostiola, interior white, fibrous; stipes one-fourth to one-half length of stroma, generally cylindric, with a brownish woolly-tomentose base, more or less simple with branching in or at the base of the fertile head. Perithecia thickly crowded, 0.33-0.5 mm.. in diameter, globose to slightly compressed, more or less erumpent. Asci cylindric with a long stipe (sometimes one-half total length of ascus), sp. p. 75-80 x 5.5-8 microns, 8-spored. Ascospores obliquely uniseriate, fusoid, inequilateral, obtuse at each end, brown to black, 9-16 x 4.5-6 microns.

Specimens examined:

Hendricks Co.: on *Acer sp.*, Dec. 26, 1912 (IU).

Monroe Co.: on ash, Unionville, Oct. 21, 1911, *Owens* (IU); on oak, Unionville, Nov. 7, 1910, *Owens* (IU); on decayed maple bark, Bloomington, Jan. 30, 1931, *Martens* (IU).

Parke Co.: on bark of *Quercus alba*, Turkey Run State Park, Trail No. 7, June 13, 1943, *Winona H. Welch 9009* (DPU).

Putnam Co.: Greencastle, April 22, 1908, *Daisy G. Lewis* (DPU); on dead fallen log, Hoosier Highlands, Sept. 16, 1941, *Simmons 1179* (DPU); on fallen, rotting log of *Salix sp.*, DePauw Arboretum, Nov. 13, 1941, *Simmons 1180* (DPU).

Rush Co.: on a rotten log, 1.5 miles N. Rushville, Dec. 28, 1932, *Floyd Shuttleworth* (DPU).

The stipes of mature specimens of *X. Hypoxylon* (L.) Grev. typically have woolly-tomentose bases while those of the occasionally similar *X. digitata* (L.) Grev. are bare.

5. *Xylaria polymorpha* (Persoon) Greville

Valsa clavata Scopoli, Fl. Carniol. 398. 1722.
Xylaria clavata Schrank, Baierische Flora, 2:566. 1789.
Clavaria digitata Bulliard, Hist. Champ. Franc. 1:192. 1791.
Clavaria hybrida Bulliard, Hist. Champ. Franc. 1:194. 1791.
Sphaeria polymorpha Persoon, Comm. fung. clav. 17. 1797.
Xylaria polymorpha (Persoon) Greville, Fl. Edin. 355. 1824.
Sphaeria digitata Müller, Fl. Danica, 15:6. 1852.

Stromata solitary or several cespitose-connected at the base, upright, thick, bare, at first dirty-brown, becoming black, not shiny, variable in size, 2-11 cm. high and 0.5-3 cm. thick, irregular in shape; simple, cylindric, subattenuated above and below, mostly obtuse; obovate, compressed; more or less sublobate-divided; globose; or otherwise variable in form. Perithecia crowded, compressed, 0.5-1 mm. in diameter, ovate or globose. Ostiola papilliform. Asci cylindrical, long stipitate, 8-spored, sp. p. 120-180 x 7.5-10 microns. Ascospores uniseriate, elliptical or fusoid, subacute at the ends, subinequilateral or curved, continuous, brown, 20-30 x 6-10 microns.

Specimens examined:

Monroe Co.: on *Acer sp.*, Unionville, Nov. 7, 1910, *Owens* (IU).

Montgomery Co.: on stump, July 27, 1917, *Sylvia Fuson 110* (MU); on old wood, near Crawfordsville, *Bruce Fink 182* (MU); Bal Hinch, S. W. Crawfordsville, Oct. 9, 1940, *Simmons 1103* (DPU).

Putnam Co.: at base of stump on hillside, Monon Springs, Greencastle, Oct. 1, 1932, *Shuttleworth* (DPU); on ground at Monon Springs, near Greencastle, *R. W. Barnett* (DPU), on stump of tree, Greencastle, April 18, 1908, *Florence Miecae* (DPU); on locust stump, Putnamville, May 25, 1908, *Minnie Bowen* (DPU).

Tipton Co.: on wood, George Auble yard, Kempton, Aug. 2, 1929, *G. Auble, Jr.* (WAB).

Union Co.: on logs in wood, July 25, 1917, *Bruce Fink 76* (MU).

Some forms of stromata of *X. polymorpha* (Pers.) Grev. may resemble those of *X. castorea* Berk. Ascospore measurements serve in making a distinction between the two species, those of *X. polymorpha* (20-30 x 6-10 microns) being relatively larger than those of *X. castorea* (7-15 x 4-7 microns).

6. *Xylaria subterranea* (Schweinitz) Saccardo

Sphaeria subterranea Schweinitz, Syn. fung. N. Am. 189. 1831.
Xylaria subterranea (Schweinitz) Saccardo, Syll. fung. 1:338. 1882.

Stromata filiform, simple or branching from the base, attached to the matrix by a thin, felt-like subiculum, 3 inches to nearly a foot in length, 1-2 mm. thick, at first light-colored from the conidial layer,

then black, sterile at the apex. Perithecia ovate-globose, about 0.5 mm. in diameter, unequally crowded or scattered at intervals along the stroma, solitary or 2-4 together, prominent, with conic-papilliform ostiola. Asci (sp. p.) cylindrical, 75-85 x 5 microns, with slender stipes and abundant paraphyses. Ascospores uniseriate, oblong-elliptical, attenuated at the ends, subinequilateral, 10-12 x 4-5 microns.

A collection of *X. subterranea* (Schw.) Sacc. is reported for Indiana by Van Hook.[11] The specimen is not found among other collections deposited in the herbarium of Indiana University. The species is included in the present study on the basis of Van Hook's report.

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The Study of a Cause of the Variation of the Antibiotic Properties of a Bacterium

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Antagonisms indicate the antibiotic possibilities of a microorganism. If one organism hinders or prevents the growth of a second it is said to be antagonistic to that organism. Antagonism may be caused by one organism over crowding the second organism, or by one organism utilizing the nutrients and thus causing the second organism to stop growing, or by one organism producing a substance which is toxic to a second organism.

A bacterium was isolated from a germinating Kentucky bluegrass seed after it was observed to inhibit *Rhizopus nigricans*. It was decided that this organism should be studied for its possible antibiotic properties. *Rhizopus nigricans* is a difficult fungus to inhibit because of its stoloniferous nature. Originally the bacterial inhibitor was so powerful it not only inhibited Rhizopus at a considerable distance, but it affected this mold in such a manner that it tended to pile up on the opposite side of the plate from the inhibitor.

This bacterium produced a thermostable substance which inhibited *Rhizopus nigricans, Helminthosporium carbonum,* and *Trichophyton inter-digitale.* After several months and repeated subcultures, the culture lost all ability to inhibit *Rhizopus nigricans.*

A microscopic examination of the bacterial culture revealed the organisms were rods of approximately the same size and shape and from microscopic examination there was no evidence that we were working with a mixed culture.

The possibility of a mixture of strains was investigated. The bacterium was plated using standard dilution techniques and a study of individual colonies were made. Seven types of colonies were recognized and studied.

Variant number 1 grew with a spreading growth on a slant with a glossy center and dull edges. It was a circular, flat, opaque colony with a moruloid surface and erose margin.

Variant Number 2 grew with a spreading growth on a slant, with a glossy center and dull edges. It was a circular to slightly irregular, flat colony, glossy and translucent in the center, dull around the edges with a moruloid surface and erose margin.

Variant Number 3 grew with a spreading growth on a slant, glossing in the center and dull and opaque around the edges. It was a circular, convex colony with a tendency to produce concentric buckles. It was opaque with moruloid surface and undulate margin.

Variant Number 4 grew with a spreading growth on a slant, was

glossy in the center with dull edges. It was a flat, circular, opaque colony with a moruloid surface and erose margin.

Variant Number 5 grew with a spreading growth on the slant and was glossy and translucent. The colony was circular, raised, and translucent with moruloid surface and undulate margin.

Variant Number 6 grew with an echinulate growth on the slant. The colony was irregular, raised in the center, translucent with a finely granular surface and entire margin.

Variant Number 7 was filiform on the slant. The colony was circular, raised in the center, translucent with a finely granular surface and entire margin.

It will be seen from this analysis that these strains do not show a great deal of visibile variability. This would strengthen the idea of species purity. However there were slight growth variations in these various strains and they were tested to determine their power to inhibit.

No difference was noted in differential media. All strains were gram-positive, motile rods. In nutrient broth, a pellicle was formed but no sediment was produced. Geletin was liquified glucose and sucrose were fermented with the production of acid but no gas. Lactose was not fermented. Nitrates were reduced to nitrites. No indole was produced. No hydrogen sulfide was produced. There seems to be a tendency for some of these variants to revert to a common form.

The original culture and all variants were tested against Helminthosporium, Rhizopus, and Trichophyton.

There was no difference in the inhibition of Helminthosporium by any of the variants or the original culture. However, when Rhizopus was used as a test organism variants Number 3, Number 6, and Number 7 inhibited Rhizopus. The other strains showed no antagonism to Rhizopus.

When *Trichophyton interdigitale* was used as a test organism variants Number 3, Number 6 and Number 7 inhibited Trichophyton. Variants Number 6 and Number 7 were better inhibitors producing antagonism from a greater distance. The other strains produced no antagonistic substance for Trichophyton.

Trichophyton interdigitale is the organism causing "athletes foot". It would be of value to find an organism that could produce an antagonistic substance to inhibit Trichopyton. If the substance could be isolated it could be used as treatment for the disease. Many antibiotic substances have looked promising on a test plate but have proven toxic when used internally as treatment for disease. The danger of toxicity in the antibiotic treatment of Trichophyton is not great because it is an external disease and local treatment could be made.

It is apparent that the culture is made up of a number of different strains. The strains differ in their antagonistic characteristics. If some of the ineffective strains dominate the culture, the whole culture is impotent. If, on the other hand, the antagonistic strains dominate the culture, antagonisms toward fungi are exhibited in varying degrees. It seems reasonable that this is an adequate explanation for the variations of antagonisms shown by the original culture.

Isolation of Blue-green Algae for Pure Culture

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Within the last few years, the study of Algology has been developed from a scientist's science, carried on by a relatively few physiologists and taxonomists to an active, rapidly-growing field of research. The sudden surge of popularity is due to the ever-widening search for organisms which might be capable of elaborating antibiotic substances. All groups of plants have been investigated; however, the Thallophytes have received the most careful examination so far because they have, up to the present, been the most prolific producers of antibiotics. The bacteria, from which are obtained eumycin, subtilin, and gramicidin, among the most prominent; the actinomyces, from which are obtained streptomycin and streptothrycin; the molds, which produce penicillin, flavacin, and Kojic acid; and the algae, producers of chlorellin. The higher plants, moreover, have not been neglected; some of them, for instance the common garlic, have been found to contain an antibiotic substance.

As was mentioned before, the algae have been investigated and still are being investigated. Most of the research has been, however, on the green algae, since *Chlorella vulgaris*, a green form, is known to secrete an antibiotic. The blue-greens, as a whole, have been neglected for several reasons:

1. Cultures have been considered difficult to secure; under most favorable conditions, the blue-greens do not produce as conspicuous or luxuriant growths as other forms. As a group, they are exceedingly small and tedious to work with.
2. Because of a gelatinous sheath which is secreted by the cell wall and harbors bacteria, bacteria-free cultures have been difficult to obtain.
3. Methods of cultivating the blue-greens for large-scale production have been difficult because of their nutritional idiosyncrasies and the difficulty of satisfying their light requirements.

In the face of so many difficulties, it may seem strange that an investigation of their antibiotic properties would be attempted; however, there are several reasons why such a project seems logical. First, the medicinal properties of antibiotics found so far (especially penicillin) have proved to be so unique that no group of organisms should be neglected in the search. Second, since so many bacteria have been found to elaborate antibiotic substances, it seems probable that organisms so closely related to the bacteria as these simplest algae may be capable of producing antibiotics. Third, blue-greens, simple as they are, are capable of living and reproducing in surroundings in which competition for *lebesraum* is keenest. They are found in drainage waters, pools rich

in organic matter, the alimentary tracts of higher animals (including man), and soils high in organic content—all situations in which other forms are numerous and vying for their share of space and food. It seems logical that their ability to compete against other forms may be due to a production by them of some substance that may inhibit or at least discourage growth of other organisms. It is a well known fact that some algae are capable of rendering water unfit for animal consumption and that others prevent normal root function of some of the higher plants. Fourth, the pigment phycocyanin, peculiar to the blue-green algae, may, like other plant pigments, such as chlorophyll, be capable of inhibiting growth. Five, the strains of bacteria which are consistently found associated with the algae may, in themselves, be antibiotic.

In isolating cultures of blue-greens for studies, in the past, bacteriological techniques have frequently been employed to obtain unispecific cultures—and, when possible, bacteria-free. Streaking of a loopful of cell suspension in a grid pattern on nutrient solution plus 2% agar, followed by picking off and transfer to other media has frequently been employed. Agar dilution methods have been favorites also, both the usual bacteriological techniques and one which calls for flooding an agar plate with a dilute suspension of cells and allowing the water to evaporate, "stranding" isolated cells. This is followed by picking off the single cells or colonies and transferring them to other media. These methods, however, do not guarantee bacteria-free cultures as the bacteria remain in the sheaths and ride along with the algae.

Although the cells of the blue-greens are seldom completely devoid of their mucilaginous coating, there are times when this covering is reduced to a minimum. After adverse conditions, the cyanophyceae may produce endospores, exospores, or akinetes, which can be isolated by single-spore techniques with a micromanipulator or dilution methods. This is an exceedingly tedious task, however.

The author of this paper, in work with the blue-greens, has attempted first to isolate the algae in unialgal or uni-specific cultures. One method which can be employed in the laboratory has been worked out by Lewis Flint, algalogist at Louisiana State University. It is applicable to isolation of algae from soil samples. The soil is sprinkled in a light layer over the bottom of a sterile petri dish and covered with a thick layer of silica sand. The sand is moistened with a nutrient solution, such as Krop's or Detmer's, and the plate is placed about 6-8 inches below the tubes of an ordinary fluorescent lamp. The plate is kept moistened and in from 2 weeks to 4 weeks, algal colonies appear on the surface. These colonies can be picked from the sand surface with the aids of dissection binoculars. After the colonies are picked from the sand surface, they are transferred to the top layer of a stack of 5-6 sterile, moistened course filter papers in a petri dish. Eventually, the algae penetrate the various thicknesses of the paper and by discarding the top papers, one can reach a level where only one colony has penetrated. A more convenient method than the above has been devised by the author for the isolation of unispecific algal cultures from soil. Filter paper clippings (about 4 tablespoonsful) are placed in a petri dish, moistened with nutrient solution,

and autoclaved at 15 pounds pressure for 20 minutes. On top of this is sprinkled very sparingly the soil sample and the plate placed from 8-10 inches below the fluorescent tube. Colonies spread out from the soil particles; and since the filter paper holds the moisture, watering and therefore mixing of the algae is avoided. Filaments or colonies also are easier to pick from the clippings than from sand; very small portions can be removed with a sterile needle.

After isolation of uni-specific algal colonies, the next step is to free the isolate of bacterial contamination. Since bacteria prefer neutral or slightly acid media, acidification of the medium greatly inhibits their growth; unfortunately, most blue-greens will not grow in an acid medium.

In the isolation of blue-greens from solid substrates, such as rocks or pebbles, the author of this paper has found that by placing the pebbles in a sterile petri dish, covering with a thick layer of sterile 3% agar and inverting the plates near a light source, one gets abundant growth of algae on the bottom of the plate, while the molds and bacteria grow at the surface or slightly below. After illumination for 2 to 3 weeks, the surface of the plate is flooded with 1:1000 $HgCl_2$. solution for 10-15 minutes to kill surface contaminants, then the agar surface washed with sterile water 3-4 times. After this, with a right-angle needle, the surface agar can be lifted off and the alga removed to another medium.

Trelease and Selsam[1] have described a method to remove protozoan contaminants in which the cells are treated 12-24 hours with .45 M $MgSO_4$ solution. Allison and Morris[2] successfully employed ultra-violet rays to irradiate cultures, reasoning that the irradiations would have lethal affect on the bacteria present before the algae succumbed. The author has been eager to try this method; this has not been attempted up to the present.

The above methods outlined are only the beginning—only the first halting steps—in an attempt to develop techniques which can be employed in as satisfactory a manner as modern bacteriological methods.

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A Ten-year-old Forest in Lye Creek Prairie, Montgomery County

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In April 1936, on a farm, about ten miles northeast of Crawfordsville, Montgomery County, Indiana, a novel thing happened; the soil on a 60-acre tract of land caught fire. A farmer raked the cornstalks on the field into windrows and then set fire to them. The muck soil caught fire and burned for several weeks at the rate that a cigar burns. Before a

Fig. 1. The 60 acres of burned muck soil. Spring 1936. Photograph by Hirshburg.

rain came the fire had consumed the soil on half of the 60 acres to the depth of three feet which reached the blue shale which underlies this region. (Fig. 1) In some spots the soil was destroyed just a few inches. Neighboring farm land was saved by digging a trench three feet deep around the burning land.

To-day, ten years later, many of these acres are covered with exactly what the word jungle suggests to most people. Where the soil

burned down to the shale we find to-day a flora making a tangled mass of shrubs and trees ranging from five feet to twenty feet tall. Where the burning was to lesser depths a rank herbaceous growth holds its own. The latter plant growth came from seeds that lay in the soil below the level reached by the combustion and from seeds carried in by the wind. This vegetation is composed of grasses, sedges, smartweeds, swamp milkweed, goldenrods, asters, bugleweeds, cattails, etc. Trees had no chance to grow on the parts where seeds of these herbs were already present. For three years following the fire, liverworts and mosses grew on the areas where a shallow surface soil layer had burned. *Marchantia polymorpha* covered many continuous square yards and many acres in all.

Where the soil burned to the shale, living seeds and propagative stems from plants which had grown on the farm land as weeds thru

Fig. 2. A fallen 10-year-old Cottonwood in the Willow-Poplar jungle. Photograph by John I. Bechtel.

the years previous to the fire were, to a great extent, destroyed in the burning. On this severely burned area, during the past ten years a young forest has grown. The species forming the young forest community at this date are the following: *Salix interior, Salix cordata, Salix sericea, Salix petiolaris, Salix nigra, Salix amygdaloides, Populus deltoides, Populus tremuloides, Platanus occidentalis, Ulmus americana* (one individual), *Rhus toxicodendron, Cornus stolonifera, Cornus asperifolia,* and *Vitis vulpina.* We will note that the seeds of these plants were carried in by the wind or dropped by the birds.

The growth of the shrubby willows makes almost an impenetrable thicket over much of the wooded area. Here is the first known station for *Salix amygdaloides,* the Peach-leaved willow, in Montgomery County. Deam in his Flora of Indiana indicates that the nearest station

for this willow is about 50 miles distant. However there must be stations nearer than 50 miles yet to be listed. This species is abundant in this forest. Also there is in this young forest a herbaceous floor cover coming in at this date, species of which represent thirty different genera.

On tramping through this forest to-day one meets fallen willows and fallen poplars in all stages of decay. (Fig. 2.) Many of these fallen trees have trunks twelve inches in diameter. I have three reasons to offer for the short lives of these woody plants. First, the soil is very shallow and is composed mainly of coarse organic matter lying on a bed of shale. In this substratum the tree roots have little opportunity to find sufficient anchorage. Secondly, there is always subterranean water standing on the shale. This is easily observed in muskrat holes and where man tramps through the thin soil layer. Thirdly, whenever good rains come this area becomes flooded and water stands a few inches to two feet in depth for three to four weeks. It gradually drains off through vegetation choked drainage ditches. This standing water must become very short in a supply of oxygen. Because of these three reasons I believe that this Willow-Poplar forest will be short lived. I will venture a prophecy here, namely, that in not very many decades this forest will be succeeded by a grassy prairie like unto what it was before the land was broken for cultivation.

So far I have been talking about a tract of land which lies in the midst of what folks during the past century called the Lye Creek Prairie. In the fall of 1920 a native of Crawfordsville took me to see what he called a "real Montgomery County Prairie". He took me to a twenty-five acre tract of land which was just across the roadway northward from where the young forest described is now growing. The prairie visited then had been pastured but had never been touched by farm machinery. The grass was very thick on the ground. As we walked over it we frequently came to grassy ponds of water which were over shoe top and sometimes knee deep on us. Several flocks of wild ducks flew up ahead of us. I have heard sportsmen relate about the great hauls of wild ducks which were made decades ago from the Lye Creek and Potato Creek Prairies in the northeast part of Montgomery County.

Frequently from 1921 to 1928 I took my special students to this spot to show them a bit of open grassy prairie. On our visit in late May of 1928 we did not see a prairie but a stretch of black earth with corn seedlings peeping through its surface. A native son told us "The drainage ditch was deepened and a tractor did the rest". However, the cultivation of much of this prairie has not proved profitable. Heavy rains always turn it into lakes of water.

We have been told that prairies were treeless because there was not enough water to support tree growth, and, that the Indians set fire to them in order to destroy the tree growth. But in the case of this Lye Creek Prairie the tree growth is lacking because the amount of water present is excessive. Level of the water table is too high in this area for tree growth. In the ten-year-old Willow-Poplar forest which is now attempting a tree stand we find the water table to be just a few inches below the surface of the newly forming soil.

We have mentioned above that the willow shrubs, the willow trees, and the poplar trees are dying and toppling over. (Fig. 2) They took hold here following the fire because they had no competition. They have made a good start and are propagating themselves to some degree but the development of the herbaceous ground cover has begun to interfere. The older shrubs and trees are dying, although still in their youth. They are dying because of one operative factor in their habitat, namely, poorly aerated standing excess water. I believe that in the not distant future this willow-poplar forest and the land bordering upon it that has been intermittently farmed will return to its former state, namely, an open grassy prairie. Man would show wisdom by helping it to do so.

A New Technique in the Artificial Culture of Nematodes

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Techniques in the artificial culture of nematodes (Heterodera species) and their infestation of plant roots have been reported by Christie of the United States Department of Agriculture, Barrons of the Alabama Experiment Station and other workers. Their work however dealt mainly with host-parasite relationships and susceptibility studies. Because of the nature of their investigations, the techniques usually consisted of inoculating sterile soil with a water suspension of nematode larvae and eggs. In other instances, plants were grown directly in nematode infested soil, or in soil inoculated by the use of chopped root galls containing larvae and eggs. These techniques, no doubt were quite adequate for the types of investigations which were conducted. However if it is desired to observe the movement of the nematode larvae and their development in relation to the plant root or many other series of examinations, an opaque material such as soil is not satisfactory. Therefore, the following technique deals with the preparation and use of a clear medium in these cultural studies.

Materials and Method

A one per cent water agar was prepared and all other organic materials such as potatoes and sugars were excluded. These organic materials usually render a medium less transparent unless special means of clarification are followed. Furthermore, these organic materials were not needed in this study, as the addition of the essential mineral elements for higher plant growth was satisfactory. The medium was then placed in small test tubes (10 x 100 mm.) The tubes were filled ½ full, plugged with cotton and sterilized. Upon cooling and solidifying, the medium was sufficiently clear to permit microscopic low power examination.

Growing Lettuce Seedlings in the Tubes

Lettuce seeds were lightly surface sterilized in a five per cent hydrogen peroxide solution for 15 minutes. This treatment eliminated most of the common surface spores and did not injure the seed embryos. The seeds were then given one washing in sterile distilled water in order to remove excess hydrogen peroxide. Next, the seeds were placed between moist sterile filter papers in petri dishes for germination. After about 72 hours or when the primary root was ¼ to ½ inches long, the tiny seedlings were transferred to the small test tubes for further growth. This transfer was accomplished by the use of sterile forceps. The seedlings were handled gently, placing one seedling in each test tube

and forcing the primary root into the surface of the medium. Further growth was soon evident as determined by the downward extension of the root system and growth of the shoot.

Nematode Inoculation of the Tubes

After about two days of seedling growth, the nematode inoculum was added. Several root-knot galls, the infested part of older lettuce roots, were cut from the plants. The surface of the galls were examined, with the aid of the binoculars, for the presence of a yellowish-brown material, the gelatinous matrix in which the eggs are imbedded. When this gelatinous matrix was found, a very small amount was placed in the depression of a well slide in a few drops of sterile distilled water. A low power microscopic examination revealed numerous nematode larvae and eggs in this suspension. A very small loopful of this suspension was used to inoculate the agar surface of each test tube. Before the inoculation was made, the loopful of suspension was examined under the microscope in order to ascertain the relative population of larvae and eggs in the film of water. The wire loop containing the suspension was held steady for microscopic examination by attaching the handle to a clamp stand and placing the loop at about the stage level of the microscope.

Results

After inoculation, the tubes were examined daily for the presence of larvae and to study their movement. This was accomplished by placing the tube horizontally on the microscope stage, and then focusing on the primary root of the lettuce seedling. Three days after inoculation, nematode larvae were observed near the seedling root tip. While gall formation was not secured, the larvae appeared to feed at the surface of the primary root near the growing point.

Contamination by fungi was of little consequence in this technique. The common molds which could be introduced in the transfer of the inoculum were observed in only a few cases, and these grew only on the surface, thus not obscuring the view of the seedling root.

Summary and Conclusions

The use of this technique in the artificial culture of nematodes should prove satisfactory in preliminary plant susceptibility studies. This technique may also be useful in a study of the movement of different nematode species and races.

Additional Distribution Records of Hepaticae in Indiana

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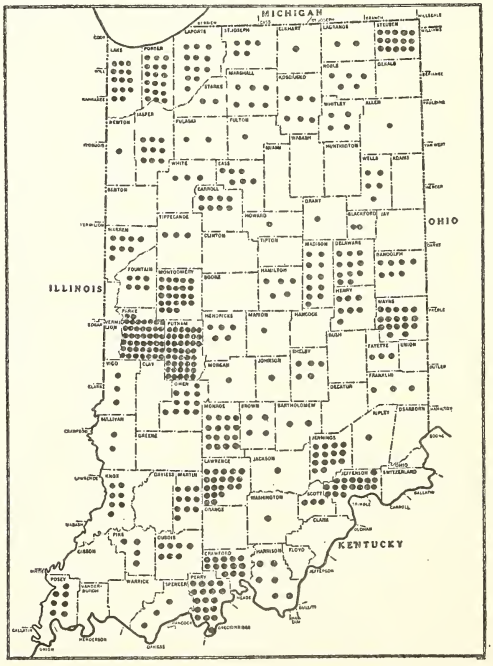
The study of liverworts in Indiana during the last ten years is represented principally by four publications by Dr. Dorthy Parker. These papers have increased considerably the number of species known to occur in Indiana and have added much information concerning the distribution of species within the state. During the past year, a study of several collections of Indiana liverworts has extended the known local distribution of a number of species. However, there is still much work to be done as is indicated by the accompanying map which shows the number of species reported for each county. This number represents the total of all reports of Indiana liverworts starting with that of Mary P. Haines in 1879. Reference to the map shows that twenty-seven counties still have no species reported and twenty-eight counties have only one to four species reported.



Number of species of liverworts reported for each county as of October 1, 1946. One dot represents one species.

The writer is indebted to Dr. T. G. Yuncker and Dr. Winona H. Welch for suggestion of the problem and for their counsel throughout the study; to Dr. Donald Richards, Chicago Museum of Natural History, for the loan of specimens; to Dr. Fred Seaver, New York Botanical Garden, for making the resources of that institution available; to all those whose names appear as collectors of the specimens cited, among whom is mentioned in particular Dr. Welch whose extensive collection of liverworts forms the basis of this study.

The list of specimens examined gives only new county records and no attempt is made to give all of the citations found for each county. Unless otherwise stated, all specimens may be found in the DePauw University herbarium. Specimens to be found in the herbarium of the Chicago Natural History Museum are indicated by C.M. following the citation; those in the New York Botanical Garden Herbarium by N.Y.

Specimens Examined

Ptilidium pulcherrimum (Weber) Hampe: Delaware Co., Apr. 10, 1938, E. Harger 334; Henry Co., Apr. 10, 1936, E. Harger 175; Parke Co., July 19, 1937, W. H. Welch 6825 in part; Steuben Co., Oct. 27, 1945, K. Wagner 754.

Blepharostoma trichophyllum (L.) Dumortier: Putnam Co., Mar., 1935, W. H. Welch 8350 in part.

Trichocolea tomentella (Ehrhardt) Nees: Laporte Co., Aug. 13, 1935, C. Deam 56,586.

Calypogeia Trichomanis (L.) Corda: Jasper Co., Apr. 7, 1939, W. H. Welch 8673, 8722; Mongomery Co., Aug. 6, 1937, W. H. Welch 8893, 8909; Porter Co., July 27, 1935, W. H. Welch 8279, 8550; Putnam Co., Oct. 13, 1945, K. Wagner 696, 701.

Cephalozia media Lindberg: Putnam Co., Oct. 13, 1945, K. Wagner 710 in part.

Cephalozia connivens (Dickson) Lindberg: Montgomery Co., Aug. 6, 1937, W. H. Welch 8904 in part; Parke Co., Nov. 5, 1945, K. Wagner 800; Steuben Co., Oct. 27, 1945, K. Wagner 769, 801.

Nowellia curvifolia (Dickson) Mitten: Jefferson Co., July 8, 1937, W. H. Welch 8513; Steuben Co., July 18, 1935, W. H. Welch 8189.

Lophocolea heterophylla (Schrader) Dumortier: Cass Co., Nov. 26, 1937, W. H. Welch 8679, 8690; Carroll Co., Aug. 5, 1935, W. H. Welch 5344, 8526; Delaware Co., Apr. 10, 1938, E. Harger 340; Harrison Co., July 10, 1937, W. H. Welch 8790; Henry Co., Apr. 12, 1936, E. Harger 71; Jasper Co., July 25, 1935, W. H. Welch 8848; Knox Co., July 12, 1937, W. H. Welch 7823; Lawrence Co., Sept. 5, 1946, K. Wagner 1361; Madison Co., Aug. 7, 1935, W. H. Welch 5830, 5831; Marshall Co., July 17, 1935, W. H. Welch 8390, 8506; Monroe Co., May 3, 1931, W. H. Welch 8315; Noble Co., Sept. 5, 1935, W. H. Welch 8531, 8533; Starke Co., July 16, 1935, W. H. Welch 8485, 8507; Steuben Co., Oct. 27, 1945, K. Wagner 757, 802; Warren Co., Nov. 27, 1937, W. H. Welch 8684, 8701; White Co., Aug. 6, 1935, W. H. Welch 8495.

Lophocolea minor Nees: Carroll Co., Aug. 6, 1935, W. H. Welch 8319; Jasper Co., Aug. 30, 1935, W. H. Welch 8833; Porter Co., July 26, 1935, W. H. Welch 8537, 8543; Steuben Co., July 18, 1935, W. H. Welch 8519 in part.

Geocalyx graveolens (Schrader) Nees: Marshall Co., July 17, 1935, W. H. Welch 8534; Montgomery Co., Aug. 6, 1937, W. H. Welch 8904; Noble Co., Sept. 5, 1935, W. H. Welch 8373; Porter Co., July 26, 1935, W. H. Welch 8600; Steuben Co., July 18, 1935, W. H. Welch 8377.

Chiloscyphus pallescens (Ehrhardt) Dumortier: Jennings Co., July 3, 1937, W. H. Welch 6331, 8711; Lawrence Co., Sept. 5, 1946, K. Wagner 1359; Madison Co., Aug. 7, 1935, W. H. Welch 8185, 8492; Martin Co., July 1, 1937, W. H. Welch 6325; Owen Co., June 30, 1937, W. H. Welch 6328; Steuben Co., July 18, 1935, W. H. Welch 8530, 8544.

Jungermannia lanceolata Schrader: Parke Co., Nov. 5, 1945, K. Wagner 797, 799.

Jamesoniella autumnalis (De Candolle) Stephani: Delaware Co., Aug. 8, 1935, W. H. Welch 8471; Parke Co., 1937, R. Drexler 1129; Perry Co., July 11, 1937, W. H. Welch 8196 in part; Vigo Co., Oct., 1893, L. Underwood (N.Y.).

Plectocolea crenuliformis (Austin) Mitten: Crawford Co., May 10, 1941, W. H. Welch 6832, 6834; Dubois Co., July 13, 1937, W. H. Welch 6768 in part; Fountain Co., July 18, 1937, W. H. Welch 8879; Perry Co., July 14, 1937, W. H. Welch 6359, 6824.

Plectocolea hyalina (Lyell) Mitten: Dubois Co., July 13, 1937, W. H. Welch 6770; Jasper Co., July 25, 1935, W. H. Welch 8776; Montgomery Co., Oct. 2, 1938, W. H. Welch 8914; Perry Co., July 14, 1937, W. H. Welch 6812, 8884.

Plagiochila asplenioides (L.) Dumortier: Madison Co., Aug. 7, 1935, W. H. Welch 8460; Montgomery Co., Aug. 6, 1937, W. H. Welch 8889; Porter Co., July 27, 1935, W. H. Welch 8558 in part.

Scapania nemorosa (L.) Dumortier: Jasper Co., July 25, 1935, W. H. Welch 8553; Martin Co., July 1, 1937, W. H. Welch 8509; Montgomery Co., Oct. 2, 1938, W. H. Welch 8915; Owen Co., June 30, 1937, W. H. Welch 8200.

Porella pinnata L.: Jennings Co., July 2, 1937, W. H. Welch 8710; Knox Co., July 12, 1937, W. H. Welch 6762, 8576; Lawrence Co., Sept. 5, 1946, K. Wagner 1354; Owen Co., July 3, 1942, W. H. Welch 7514 (N.Y.); Perry Co., July 14, 1937, W. H. Welch 8562; Randolph Co., Oct. 21, 1945, K. Wagner 746.

Porella platyphylla (L.) Lindberg: Cass Co., Apr. 6, 1939, W. H. Welch 8739; Harrison Co., July 19, 1937, W. H. Welch 8789; Hendricks Co., Mar. 5, 1946, K. Wagner 804, 806; Kosciusko Co., Aug. 30, 1941, W. H. Welch 8463; Noble Co., Sept. 5, 1935, W. H. Welch 8286; Owen Co., May 23, 1937, W. H. Welch 8169; Porter Co., July 7, 1929, P. C. Standley 57,287 (C.M.); Posey Co., July 12, 1937, W. H. Welch 8561; Pulaski Co., July 16, 1935, W. H. Welch 8190; Steuben Co., July 18, 1935, W. H.

Welch 8219, 8545; Wayne Co., Oct. 9, 1939, King 63; White Co., Aug. 6, 1935, W. H. Welch 8394; Whitley Co., Aug. 11, 1935, E. Harger.

Porella platyphylloidea (Schweinitz) Lindberg: Blackford Co., Mar. 29, 1936, E. Harger 87; Grant Co., Mar. 20, 1938, E. Harger 233; Harrison Co., July 19, 1937, W. H. Welch 7818; Henry Co., Oct. 5, 1940, W. H. Welch 6338; Hendricks Co., Mar. 5, 1946, K.Wagner 807, 811; Lawrence Co., Sept. 5, 1946, K. Wagner 1365; Martin Co., July 1, 1937, W. H. Welch 8867, 8871; Morgan Co., Sept. 20, 1941, W. H. Welch 8172; Noble Co., Sept. 5, 1935, W. H. Welch 8231, 8378; Owen Co., May 12, 1935, W. H. Welch 5862, 5866; Scott Co., July 9, 1937, W. H. Welch 8784; Steuben Co., Oct. 27, 1945, K. Wagner 770; Washington Co., July 9, 1937, W. H. Welch 8218; White Co., Aug. 6, 1936, W. H. Welch 8504; Whitley Co., Aug. 11, 1935, E. Harger.

Radula complanata (L.) Dumortier: Jefferson Co., Mar. 26, 1939, W. H. Welch 8827; Putnam Co., May 25, 1935, W. H. Welch 8208.

Frullania inflata Gottsche: Crawford Co., July 10, 1937, W. H. Welch 6774; Jefferson Co., July 8, 1937, W. H. Welch 8579; Posey Co., May 11, 1935, E. Harger.

Frullania riparia Hampe: Delaware Co., Aug. 8, 1935, W. H. Welch 8473; Fountain Co., July 18, 1937, W. H. Welch 8876; Harrison Co., July 10, 1937, W. H. Welch 8787; Hendricks Co., Mar. 5, 1946, K. Wagner 815; Jennings Co., May 22, 1942, W. H. Welch 8380, 8573; Knox Co., July 12, 1937, W. H. Welch 8510; Kosciusko Co., July 20, 1935, W. H. Welch 8168; Lawrence Co., Mar. 23, 1933, Kriebel 126; Owen Co., Oct. 1, 1940, W. H. Welch 8640; Posey Co., May 13, 1939, W. H. Welch 8660; Steuben Co., July 18, 1938, W. H. Welch 8221.

Frullania eboracensis Gottsche: Brown Co., Oct. 21, 1945, W. H. Welch 8396; Cass Co., Oct. 6, 1939, W. H. Welch 8743; Dubois Co., July 13, 1937, W. H. Welch 8205, 8206; Hendricks Co., Mar. 5, 1946, K. Wagner 812, 814; Henry Co., Oct. 10, 1940, W. H. Welch 6339; Jackson Co., July 2, 1937, W. H. Welch 8213, 8781; Jasper Co., July 11, 1935, W. H. Welch 8837; Kosciusko Co., Aug. 30, 1941, W. H. Welch 8462; Madison Co., Aug. 9, 1935, W. H. Welch 8188, 8477; Martin Co., July 1, 1937, W. H. Welch 8869; Porter Co., Sept. 21, 1897, E. J. Hill 311/1897; Posey Co., May 13, 1939, W. H. Welch 8658, 8659; Pulaski Co., July 16, 1935, W. H. Welch 8210, 8212; Starke Co., July 16, 1935, W. H. Welch 8508; Steuben Co., Oct. 27, 1945, K. Wagner 758; Warren Co., Nov. 27, 1937, W. H. Welch 7828, 8697; Whitley Co., Aug. 11, 1935, E. Harger.

Frullania Brittoniae Evans: Carroll Co., Sept. 6, 1935, W. H. Welch 5843 in part; Harrison Co., July 10, 1937, W. H. Welch 8788; Hendricks Co., Mar. 5, 1946, K. Wagner 816, 818; Lawrence Co., Sept. 5, 1946, K. Wagner 1363; Parke Co., July 17, 1937, W. H. Welch 6308; Scott Co., July 9, 1937, W. H. Welch 8783, 8786.

Frullania squarrosa (Blume, Reinwardt, Nees) Dumortier: Monroe Co., May 1893, L. Underwood (N.Y.); Montgomery Co., Sept. 11, 1942, W. H. Welch 8122; Pike Co., July 16, 1937, W. H. Welch 6366; Scott Co., July 9, 1937, W. H. Welch 8782, 8785; Spencer Co., July 14, 1937, W. H. Welch 6361, 6362; Warren Co., July 18, 1937, W. H. Welch 6348.

Jubula pennsylvanica (Stephani) Evans: Dubois Co., July 13, 1937, W. H. Welch 6768 in part.

Leucolejeunea clypeata (Schweinitz) Evans: Perry Co., July 17, 1937, W. H. Welch 6764, 8197.

Cololejeunea Biddlecomiae (Austin) Evans: Jefferson Co., July 18, 1937, W. H. Welch 8202, 8293; Lawrence Co., Sept. 5, 1946, K. Wagner 1355 in part; Madison Co., Aug. 7, 1935, W. H. Welch 8500; Parke Co., Oct. 13, 1945, K. Wagner 728; Perry Co., July 15, 1937, W. H. Welch 6357 in part.

Pellia epiphylla (L.) Corda: Crawford Co., May 10, 1941, W. H. Welch 6833; Dubois Co., July 13, 1937, W. H. Welch 6772; Montgomery Co., Oct. 2, 1938, W. H. Welch 8913; Perry Co., July 11, 1937, W. H. Welch 8294, 8516.

Pallavicinia Lyellii (Hooker) S.F. Gray: Marshall Co., July 17, 1935, W. H. Welch 8537.

Riccardia pinguis (L.) S.F. Gray: Steuben Co., Oct. 27, 1945, K. Wagner 762.

Marchantia polymorphia L.: Blackford Co., July 16, 1905. C. Deam 42; Harrison Co., Oct. 1, 1926, C. Deam 43,879; Jasper Co., July 25, 1935, W. H. Welch 8589; Madison Co., Aug. 7, 1935, W. H. Welch 8266; Montgomery Co., Oct. 16, 1938, W. H. Welch 8733, 8734; Noble Co., June 11, 1916, C. Deam 20,113A; Steuben Co., July 18, 1935, W. H. Welch 8249; Wells Co., July 23, 1905, C. Deam 88.

Preissia quadrata (Scopoli) Nees: Madison Co., Aug. 7, 1935, W. H. Welch 8446, 8459; Porter Co., July 27, 1935, W. H. Welch 8863; Putnam Co., Oct. 13, 1945, K. Wagner 726.

Conocephalum conicum (L.) Wiggers: Delaware Co., Aug. 9, 1935, W. H. Welch 8496; Howard Co., 1934, C. M. Ek; Jefferson Co., Mar. 25, 1939, W. H. Welch 8832; Martin Co., July 1, 1937, W. H. Welch 8269; Owen Co., June 30, 1937, W. H. Welch 8855; Perry Co., July 11, 1937, W. H. Welch 8318; Porter Co., June 21, 1932, S. Flowers; Steuben Co., Sept. 11, 1904, C. Deam; Tippecanoe Co., Apr. 22, 1935, W. H. Welch 8250; Warren Co., Nov. 27, 1937, W. H. Welch 8682.

Lunularia cruciata (L.) Dumortier: Monroe Co., Apr. 20, 1928, Gragg.

Reboulia hemisphaerica (L.) Gottsche, Lindenberg, Nees: Cass Co., Nov. 26, 1937, W. H. Welch 8375, 8680; Crawford Co., May 5, 1941, W. H. Welch 6830; Jefferson Co., May 22, 1942, W. H. Welch 8385, 8587; Knox Co., June, 1929, W. H. Welch 1936; Martin Co., July 1, 1937, W. H. Welch 6323, 8375; Montgomery Co., Aug. 6, 1937, W. H. Welch 8907; Sullivan Co., July 16, 1937, W. H. Welch 6348; Warren Co., Apr. 22, 1935, W. H. Welch 8479.

Asterella tenella (L.) Beauvois: Perry Co., July 11, 1937, W. H. Welch 8196 in part.

Ricciocarpus natans (L.) Corda: Monroe Co., W. H. Welch 6810; Putnam Co., May 26, 1933, W. H. Welch 8260; Randolph Co., Oct. 20, 1945, K. Wagner 741.

Riccia arvensis Hoffman: Newton Co., May 23, 1937, R. Drexler 1155; Owen Co., Oct. 1, 1940, W. H. Welch 8643; Parke Co., Sept. 4, 1946, K. Wagner 1339; Putnam Co., July 5, 1940, W. H. Welch 8976.

Riccia fluitans L.: Tippecanoe Co., July 20, 1915, C. Deam 17,732; Whitley Co., Aug. 11, 1935, E. Harger.

A Consideration of some Reports of Indiana Liverworts

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A few species of liverworts have been carried on the list of those supposed to occur in Indiana while, for one reason or another, the original report and, in some cases, subsequent identifications are questionable. If an accurate check list of Indiana liverworts is to be maintained, it is necessary not only to report new records for the state, but also to search out and delete the names of those species that have been incorrectly reported. It is the purpose of the writer to call attention to certain facts concerning five species of liverworts which would indicate that they have never actually been collected in Indiana. It is not his purpose to discredit the work of an other investigator.

The most accepted and safest criterion for the distribution of any plant is an available herbarium specimen for the region in question. Although there are a few reports where the nature of the work is such that the determination of the species involved is probably correct but no specimen is available for checking, for example, the report of *Riccia Frostii* Austin by Caroline Black,(3) it is the writer's opinion that field determination alone should not be accepted as evidence for extending the known range of any species of liverwort.

TABLE 1. A comparison of some vegetative characteristics of *Lophocolea bidentata* and *L. heterophylla.*

characteristic	bidentata	atypical heterophylla	typical heterophylla
Length of average plant in mm.	up to 50	up to 7	up to 15
Width of plant in mm.	2.5-4.0	0.5-2.0	2.0-2.5
Width of leaf in number of cells	up to 71	15-47	30-47
Length of leaf lobe in number of cells	16-26	5-11	0-11
Length of uniseriate portion of leaf lobe in number of cells	2-6	1-2	0-1
Length of biseriate portion of leaf lobe in number of cells	3-5	1-2	0-1

Lophocolea bidentata (L.) Dumortier has been reported for seven counties in Indiana. More than sixty specimens collected in this state and previously identified as *L. bidentata* have been examined and found to be examples of *L. heterophylla* (Schrader) Dumortier in which the heteromorphic leaf forms were not obvious. Fortunately, several of these had not been published. This confusion may be due to over emphasis in certain current liverwort keys of the value of the variable leaf characteristic in separating the two species. The preceding table is designed to show the most conspicuous differences in the vegetative characteristics of these species. The specimens used to obtain these data are: *L.*

bidentata: from number 258 of V. Schiffner, Hepaticae Europaeae Exsiccatae; atypical *L. heterophylla:* from a specimen recently cited by another investigator under the name *L. bidentata;* typical *L. heterophylla:* from K. Wagner 759 collected in Steuben county, Indiana.

Barbalophozia barbata (Schmidel) Loeske and *Lepidozia setacea* (Weber) Mitten were reported for Lawrence county in the same paper(1) and are considered together here for that reason. The language of the report, which states that these species, along with eleven others, were observed at Spring Mill State Park, indicates that it may have been based on field determinations. No mention is made of any specimens being collected and no herbarium material is available for study. The writer of the present paper collected several species of liverworts at Spring Mill State Park but failed to find these two. It is also noted that Frye and Clark(4) do not include Indiana in the distribution of either *Barbalophozia barbata* or *Lepidozia setacea.*

Ptilidium ciliare (L.) Hampe has been reported for Lake,(2) Putnam,(10) and Wayne counties.(7) There have been no reports of this species for Indiana since that of Dr. Underwood in 1894. The specimen upon which Dr. Underwood's report was based was studied and found to fit the present conception of *P. pulcherrimum.* The original determination of this specimen is not difficult to understand since the section on Hepaticae in the sixth edition of Gray's Manual lists only *P. ciliare.* This section of the sixth edition was edited by Dr. Underwood. It would seem that Dr. Underwood did not, at that time, recognize *P. pulcherrimum* as a valid species. It is evident, then, that the question here is one of nomenclature rather than specimen identification. If *P. pulcherrimum* is to be accepted as a species, as it is by most all present day workers in the Hepatics, then *P. ciliare* should not be included in the list of the Indiana species.

Plectocolea crenulata (Smith) Buch, Evans, and Verdoorn has been reported for Putnam county.(10) The report is based on specimens collected by Dr. Underwood and issued as number five in C. C. Haynes: American Hepaticae. Packets of this exiccatae at the University of Michigan Herbarium and at the New York Botanical Garden were examined and found to contain only *P. crenuliformis* (Austin) Mitten.

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Indiana's Changing Landscape*

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It has been announced that this is to be a philosophical discussion of the landscape assets of Indiana. I want to state in the beginning that I do not pose as a philosopher, for I know full well that I do not have the knowledge of general principles which is the attribute of philosophers. It is with diffidence that I address this society of accomplished scientists because I have a realization of my shortcomings. I have had to learn what I know about soils during the last few years and the job is still far from being well done. "In nature's infinite book of secrets little can I read." There is so much that I do not know.

I am primarily a biologist and hence have been learning of the things about me by observing living things, including man. My remarks will be tempered by the view of my environment through the glasses of a natural scientist. I have drawn some conclusions about the world in general from my more or less intimate knowledge of some small parts of it. I trust they may be correct and worthwhile. I believe one can learn a great deal of the general from studying the specific, whereas, it is impossible to know the specific by studying the general. For that reason our philosophers are usually our most impractical of men, while very simple folk may have a great deal of wisdom. I want you to be prepared to listen to some generalities, for I am compelled to talk somewhat in general terms. I think there is a place for generalists. They too, hit a mark occasionally.

I said I was no philosopher but, in my amateurish way, I do want to delve a little into the fields of natural philosophy and moral philosophy. I would like to enumerate some facts about Indiana's landscape, simply as facts, and also deal with their values. Natural philosophy (including the physical and psychological sciences) informs us about our environment and ourselves, shows us our resources and our powers, what we can do and how to do it. Moral philosophy asks the deeper and more significant question: What *shall* we do? Since we find ourselves able to steer our lives so as to change the proportion of good or bad, of light and shade, it makes a moral problem. Insofar as our relation to our landscape is concerned we must know what to choose and from what to refrain. What shall we work for in Indiana and what against?

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* Address delivered before the Indiana Soil Science Society, Lafayette, November 18, 1942. Presented to the Botany Section and by request of that section published as a memorial to Mr. Kriebel.

Landscape Defined

Before going any further I want to define my use of the term "Landscape". I believe that most of us have a good conception of what is meant by landscape as the word is ordinarily used to describe a stretch of natural country as seen from a single point, as from a hill or other vantage point. I want to use the word as it is used in soil geography to include the sum total of the characteristics that distinguish a certain area on the earth's surface from other areas. I will talk about the whole landscape of Indiana as it might be seen from a very distant point. A mind's-eye view, if you please. I would like to have you see the whole state in perspective.

If we view Indiana in perspective we will see a picture representing natural scenery the characteristics of which are the result not only of natural forces but a human occupancy and use of land. Included would be such features as rock formations, plants, animals, soil types, hills, valleys, streams, cultivated fields, roads, buildings, strip mines, lakes and drainage ditches. These and other factors would give the landscape its distinguishing pattern. In other words, my use of the word includes the complex pattern of an extensive area including all of Indiana rather than to restrict it to its narrower definitions as, for example, the hills of Brown County or the forested Plainfield sand of the Kankakee River Valley. My use of the word included the cultural features which are excluded from the term "natural landscape".

Since the pattern of the various landscapes in Indiana that make the total is due to the contributions of natural forces and upon the manipulation by humans, I want to consider the forces of nature which have brought it about and by which it maintains its existence. I also want to discuss the effect of man on it. As a biologist, I am reluctant to separate man from the landscape, for I think he is as much a part of it as any other living organism. I do so only because I think I'll be better understood. It is the effect of man on landscape which I want to discuss in more detail for he is the cause of changes which would not have come about without his aid and which would be unable to maintain themselves without his constant intervention.

Forces That Make Landscape

The forces which bring about landscape are numerous and complex. They are the forces of geology, climate and biology. The natural landscape takes on a particular pattern in response to events of the past. Because of different rock formations, changes in climate, and plant and animal life, Indiana has many physiographic and ecologic areas. Due to these great forces, we have such landscapes as those of the unglaciated area, Illinoian Plain, Wabash Valley, Kankakee area, and the lake area, and the dune area. The soils are different because of the variable factors that make soil, such as parent material, climate, biological activity, age and slope. There is a number of possible combinations of the climatic,

biological and geological forces in this state and as a result there is a great number of types of soil which yet can be grouped conveniently into larger groups that have a common property of being useful to the development of human society but not all of them having the same degree of usefulness.

All living things largely depend upon soil for nutrients. Since life depends upon the soil it is limited to those forms and numbers that can be maintained by the nutrient supply delivered by the soil. The supply of nutrients in the soil and their quality depend on climate. Not weather, as we know it from day to day and year to year, but the sum total of the weather over great ages. Climate is the great force which has made Indiana landscape. In the climate at work on the different rocks is hidden the secret of understanding how soils can be of nutrient value for life. We talk much about weather but we fail to comprehend the great force of climate. It is the force to which the limestones and the sandstones in the hills of Indiana must succumb and by which they are changed to the "sluggish clod which the rude swain turns with his share and treads upon". Climate as it breaks down our rocks has made some parts of Indiana good; other parts it has made poor as it moves the nutrients from the rocks to the sea. The soil is the resting place—a stopping off place on its journey.

The ecological array, of the plants and the animals here before the advent of man, was present as a result of the nutrient quality of the soil. Indiana was mostly forested because in the forest vegetation, in all the varieties, were the colors by which the Creator had painted the picture of the nutrient qualities of the soil. Possibly the plants were mostly of a woody nature because of the ratio between calcium, phosphorous, potassium, and the like as they were weathered from the rocks. At any rate, the forces of nature were such as to make a woody vegetation in contrast to a more proteinaceous one. On the canvas which we may call Indiana, is laid out the pattern by which the life forms (including man) which depend on vegetation can guide their own distribution, if they are to live healthily on the land.

We know quite well what the landscape in Indiana was when white man first came. Large areas were covered with forest, grassland, and swampland. Rich and varied were the natural resources. There was a harmony of life, and the forces of nature were not much disturbed by the Indians. In the rocks we find the soul of history, the whole area throbbed with life and the joy of it all was ours to share.

It is because of the nutrient quality of the soil that Indiana has such scenic areas as the hills of Brown County and such fertile farms in other parts. It is because of things that happened in the dim past that this state is a part of the world's greatest breadbasket and is fated with nine other states in the American middle west to supply sixty percent of the food for our country and our allies in this war. Indiana fortunately is located at the eastern end of the great prairies where there is great nutritive wealth. The state is fortunate because of its location, its surface space and the things that are present in that space.

The Pyramid of Life

I said that when white man came to Indiana there was a harmony of life; that there was a balance of nature. The "balance of nature" is an image that we apply to land because when our mind deals with any concept that is hard to visualize, it substitutes some familiar objects which have similarities. To me, a biologist, the balance or weighing scale, with its attribute of oscillating when balance is disturbed has never been quite satisfactory. I never see life in balance or in a static condition. Life was dynamic before we came. It is always moving. If it was in balance two hundred years ago in Indiana it was upset long ago, and the only way to get it back to that condition is to turn it back to the natural forces—"to the Indians" as the saying goes.

During recent years, because of my study and my work with Indiana soils, plants, and animals, I have learned to think of life as being pyramidal in nature. It is the image used by ecologists and presents a more accurate one of living things. It gives us an insight into the biological mechanisms. When understood, it serves as a fusion point for scientists, economists, philosophers and all laymen. It gives us a tolerance for values over and above dollars and cents. It shows that there is utility in some apparently insignificant things.

I want to offer a brief sketch of the pyramid of life in this state, and then point out or enumerate some of the changes which were made in its structure during the years since civilized man came.

In the first place I think it is necessary to know that all life derives its energy from the sun. I am able to stand here and address you because of sun energy. The source of my sun energy came to me, indirectly, through the green plant which, as far as we know, is the only organism able to utilize sunlight for the synthesis of digestible compounds for living things to eat. Everything we had to eat here this evening is the product of the green leaf, with the exception perhaps of the salt and water. The plants get their mineral nutrients such as calcium, phosphorus, potassium, magnesium, zinc, iron, sulphur and copper from the soil where it was made available to them from the rocks by the forces of climate. The carbon and part of the oxygen they derive from the air. The green leaf synthesizes them so that insects, birds, beasts and man can use them to build their bodies. If there is a sufficiency of plant nutrients in the proper solution, there will be more plants and in turn there will be more animals, because of the many plants for them to live on.

I suppose back in the days when the glaciers receded from this state the pyramid of life was not very high, but as more and more plants were evolved it was elaborated. Where there was little soil, there was little life, for there is no life without soil.

I conceive the pyramid of life to be something like this: At the base of the pyramid is the soil. On the soil grow plants of many different kinds, and large numbers of particular kinds. On the plants live a layer of insects—millions and millions of them. Then there is a layer of animals that eat the insects, such as the birds, rodents, toads, frogs,

snakes, fish and salamanders. There is a layer of animals which eat plants only, as do the elk, bison and the deer. Then there is a group of animals that eat both plants and animals. At the top are the flesh eating animals—or the carnivorous organisms, called predators.

Each layer depends upon those below. The individuals in each layer are not similar, except in what they eat. Each layer decreases in abundance from top down. For every animal that eats other animals there are many which it can eat. They in turn are dependent on large numbers of insects which live on innumerable plants. This line of dependency is called a food chain. We are dependent on these food chains the same as non-humans. At first this seems inextricably complex, but when studied, it becomes apparent how orderly the structure is.

The energy from the sun, which is absorbed by the plant, flows through a circuit of life almost like the sap flows in a tree. It flows high if the cooperations and competitions function properly. Food chains are the living channels which conduct energy upward. As the plants and animals die and decay they are returned to the soil, and again infused into living things. "Corruption is the mother of life." This applies to the life in our lakes, streams and rivers just the same as it does to organisms on drier areas.

This circuit of energy is not a closed affair. There may be loss in decay or additions by absorption. Energy may be stored as it is in the forests, soils, and muck beds. But when a change occurs in one part of the circuit other parts must adjust themselves to it. This is possible with or without detrimental effects. Nature itself has made many changes as the pyramid of life was developed. These natural changes apparently had the effect of elevating the pyramid higher and higher as nutrients were made available.

When civilized man came with his newly invented tools and techniques he cut a large part of the total pyramid to the soil line and used the soil for agriculture. Rightly so, for we could not eat the forests, and there were not enough native animals to live on. We substituted farm crops for the native plants and domesticated animals for the wild ones. Because of transportation facilities we brought in many new plants and animals; others that were already present we moved to new habitats. Some of the organisms which we brought in were very useful, others went out of bounds as pests and diseases.

Great changes have come about in the pyramid of life. Agriculture, because of over-drawing on the soil resources, or by too drastic changes of domestic plants and animals for native ones, has altered the energy circuit to such an extent that at places the pyramid is low compared to what it was before the state was used for farming and industrial purposes. The stored energy in the soils when the land was cleared for agriculture gave a false idea as to the depletion of plant nutrients. Land was often believed to be inexhaustible. Yet many soils in this state, because they were depleted of their stores, are washing and blowing away. The reaction of land to the alteration of the pyramid of life was not forseen. It was not appreciated that the pyramid of life in one part of Indiana had greater capacity to withstand manipulation than in other

parts. Because of its elasticity the corn belt can have a higher pyramid of agricultural life, than can the Illinoian plain of Scott County.

If we look at the pyramid of life as an energy circuit it shows us that (1) land is not only soil, but a fountain of energy flowing through a circuit of soils, plants and animals, (2) native plants and animals kept the energy circuit open; domestic plants and animals may or may not, (3) man-made changes are different from the natural forces and result in consequences which were not intended.

As far as Indiana landscape is concerned we need to consider two things: Can the landscape adjust itself to civilized man's doings? Can we do something about it?

The Effect of Man

Let's look at some of the changes which have been made by man in the pyramid of life during the last one hundred and twenty years.

The first thing of major importance that man did was the deforesting of areas for lumber and for soil for cultivation. As the need for more and more land was felt, he drained many areas. All the land which was cleared and drained was cultivated, fertilized and uniformly planted to useful crops. He keeps it for such purposes only by constant efforts because should he leave it alone the forces of nature in all probability would gradually bring the plants and animals back which were here originally, provided they were not completely exterminated. If all civilized folk would leave the state it would, in the long run, revert to forest, prairie, and marsh.

In the clearing and cultivating processes many living communities were sacrificed. Many plants and animals were forced out and replaced by others such as our farm crops and animals which have more usefulness. Only such wild plants and animals as were thought to be useful were tolerated. Others were ignored or fought, depending on how useful they were thought to be. Utility was always the criterion of what action to take. It was known that plants and animals compared and cooperated but they were regarded as separate and distinct. The loss of certain elements in the landscape was not believed to be serious. Little good was seen in the collective total of things.

A study of the plants and the animals in Lawrence County which I conducted some years ago, convinced me that some of the changes are indeed profound. Man transplanted plants and animals, intentionally and unintentionally. Inadvertently he introduced such plants as cheat, and bluegrass, and such insects and pests as the Japanese beetle, corn borer cabbage worm and chestnut blight. Mr. C. C. Deam in his "Flora of Indiana" reveals that of the approximately nineteen hundred species of plants which are now a definite part of our landscape, three hundred and two have been introduced since about 1820.

As a result of man's manipulation many changes have been brought about in the composition of the animal life. Forced out or back are such species as the turkey, pileated woodpecker, grouse, ducks, elk, deer, bison, and bear. Instead we have our domesticated farm animals, and such wild ones as the Hungarian partridge, ring-necked pheasant, English

sparrow, and starling. The effect of man has also caused an increase of such species as bob-white quail, meadowlark, cotton-tail rabbit, woodchuck, crow, Colorado beetle, and chinch bug.

Man has also built many houses, barns, bridges and other structures. Many of them are clustered in towns and cities. He has built highways, yards, parks and pools. Human habitations have attracted a host of dooryard weeds that grow near homesteads and animals that are closely associated with civilization, for example, barn swallows, chimney swifts, night hawks, pigeons, bluebirds, martins, bedbugs, bats, cockroaches, crickets, silverfish, house flies, mice, and rats.

He altered many waters and the aquatic life, by drainage, sewerage and industrial waste. He cleared and straightened streams and built power dams. Drainage ditches form a network over that part of the state which was once a deciduous swamp forest and is now the cornscape. Not only have the surface waters and the pyramid of life therein been profoundly changed but so have been the subterranean waters. We are somewhat in the same status as Ohio, where Dr. Stout, State Geologist, produced evidence that Ohio's water table had receded an average of 19½ feet in 20 years and that the sweet-water (potable water) table is today limited to a very thin upper crust. Indianapolis, like Cincinnati, is becoming concerned by the gradual falling of the underground water table. Below the potable water is brine.

Man has greatly accelerated soil erosion and depleted soil fertility. Scars on the land caused by sheet, gully and wind erosion are evident in nearly all parts of Indiana. On an area equal to 7% of the state, three-fourths or all of the topsoil is gone. On an area equal to one-third of the state, from one-fourth to three-fourths is removed. This means that about 1½ million acres have been so severely damaged that they are of little further use as agricultural land at present price levels. Even on our most fertile farming areas of gently rolling land, erosion is taking its toll. On level land we face declining soil fertility.

To sum up, man has been instrumental in bringing about great changes in the Indiana landscape. Primeval forest, virgin soils, and prairie grassland have given way to open fields. So great have been the changes that over most areas the natural phenomena in general are completely secondary, approachable from the agricultural or the economic rather than from the biological. Few acres have escaped the influence of man. At many places high productivity and intense agriculture have placed such a premium on every square foot of soil that landowners have been moved to do things which by hindsight we now believe were ill-advised.

I am calling attention to only some of the many changes effected by man. There are many others. Some of them are changes for the good as evidenced by many beautiful farms, highways, towns, parks, lakes, and woodlands. Other changes are definitely for the worse.

Evidences of a Stricken Landscape

In this grand state, so richly endowed by nature, there are far too many visible evidences of waste, unjustifiable destruction, exploitation,

and misuse of many of the features of its landscape: soil erosion, land exhaustion, vanished plants and animals, polluted waters and distressed people. Further evidences are decadent rural communities, blighted areas, city slums, submarginal and abandoned farms, stranded industrial towns and communities, unsightly objects disfiguring the landscape beauty, commercialization of scenic and natural areas, and unwise land use.

Even though they were once prosperous agricultural districts, there are places where the fields lie with topsoil gone and slopes gashed with gullies; grown up with poverty grass, broomsedge, sassafras, blackberries and persimmon sprouts. The inevitable poverty that accompanies such soil wastage is reflected in dilapidated barns and discouraged looking folk in unpainted houses. The wooded areas, too often, are wantonly cut over, burned and grazed.

Our cities are good only in business activity and too often quite poor in human living values. They are usually crowded, have unsightly suburbs and in or near them piles of trash consisting of a hundred and one discarded artifacts of civilized man.

The incontestible truth is that even though Indiana is still a young and growing state, evidences of decay have already begun to appear in both the urban and the rural landscape.

What We Can Do About It

After enumerating the evidences of derangement in the Indiana landscape one could say with Hamlet, "The time is out of joint. O cursed spite that ever I was born to set it right!" But we need not despair. There are many things which we can do to alter things for the better, if we will. The first task facing us is to get some new ideas into the collective thinking process of the populace.

When we talk about saving landscape we imply that it is a resource that is exhaustible and that something can be done about it; that it is controllable. To do so the following ideas should be transplanted and nurtured:

First, civilization rests squarely upon the physical and biological resources of our landscape. There are two fundamental sources of the goods and energy which man uses in the business of securing the sort of living he desires. On the one hand there is the soil, and power produced by wind and falling water; on the other hand, there are the quarry, mine and oil well. The resources of the mineral kingdom are non-renewable. In contrast the products of the soil—plants and animals—are renewable. We use them but we do not need to use them up.

Second, our greatness springs primarily from the landscape rather than from institutions. The greatness of this state is due to the greatness of the North American Continent. It is not great only because of "the American way of life", the Republican party or the New Deal. These institutions have permitted people to make use of their opportunities but no one can make an object if he does not have the where-with-all to make it. The where-with-all comes from the landscape. A pair of shoes can not be made unless the material is at hand, just as no rubber tire

can be made without rubber. No matter how much brain and mental power may be present, the landscape resources are fundamental in greatness. The people on the island of Bermuda may be very smart but Bermuda can never be what the United States is because of the lack of a number of classes of landscape assets.

Third, it is possible to preserve the physical basis of our social order through a program of conservation. This would mean a diversified program that ramifies into all the resources both renewable and non-renewable. It would involve the taking care of our soil, coal, mineral and water supply. It would involve substitution of inexhaustible or replaceable resources wherever possible, and fuller use through community, state and national planning. We are facing just such a program today in the rationing of food and rubber. Rationing is a program of conservation. Such programs can be applied elsewhere.

As far as the conservation of landscape is concerned, intelligent land use policy is the bed rock answer. The fruition of such ideas would result in biotic farming. The problem must start with the man on the land. He must be induced to keep the land in order. But the landowner cannot change his ways until his teachers, bankers, governors, editors, and neighbors change their idea of what land is for. Man controlling the pyramid of life stands in ultimate significance, for the character of the landscape is determined in a part by his enterprises. More people should realize that the landscape, like our body, should have a certain wholeness. If a part is lost it is crippled. Few realize that soil water, plants, and animals are like an engine subject to derangement.

The great task is the job of education. Many people think the way is to get hold of the schools. But here too, unless every one is back of what the children are taught, they cannot hear what is said because what is done speaks so plainly. We will have to carry the lessons right out to busy and skeptical grown-ups. It will be no easy job.

The mental process is important. It is in our minds that the changes need to be made first. We need a wholesome respect for the outdoors; an intolerance for a denuded and disorderly landscape. We need to get rid of the psychological heritage of a lazy willingness to tolerate gullied areas, over-cut and gameless acres. We are too careless about the appearance of our surroundings. We get used to untidy areas. Gradual ravishment of the landscape is too commonplace to arouse concern. Year to year changes are often so nearly imperceptible as to pass unnoticed even though profound. A shingle blowing off the roof is permitted to reach ten. We then say, "It's too bad but it can't be helped". We think too much in terms of cash returns of a year instead of the civilization of a century. Somehow we must learn to substitute scientific and biotic agriculture for an unintelligent use of land; good forestry for reckless timber slashing.

It is important to understand that the energy to control our landscape is essentially a product of that landscape for it supports the belief that man is not a detached manipulator, free to do what he will in the world in which he finds himself. Instead he is a part of the very landscape to which he belongs. He is a block in the pyramid of life.

Modification of the landscape was inevitable. This is an agricultural state and therefore agricultural enterprises take priority. The development of a farming community, however, is no valid excuse for the loss of interesting and necessary parts of the environment, which could just as well be retained by simple management. The decline of soil fertility and the loss of native plants and animals does not have to follow as an inevitable corollary of progress. It only denotes an indifferent or a bunglesome handling of a heritage.

My thesis is that we can live with nature far more harmoniously than we have been doing. But we must make compromises; we must reverse or modify our old idea that the landscape owes us everything while we owe it nothing. The very least we can do is to study, recognize, and obey natural laws. I contend that there is no such thing as wasteland. If you have the biotic point of view you see significance in the meanest plant and animal. Every nook and corner has a value. In this state each little area should be made to produce its share of the income either directly as a cash crop, feed crop, pasture, as fuel, timber, or other forest products, or indirectly as game cover or game feed, as recreational ground, wind protection or as an aesthetic background, which will make the state more attractive and, therefore, more valuable. There is utility in the total landscape.

Since man must make the use of land pay he must also be very certain that he knows what we mean by "making it pay". If in the process he loses the essential part of his landscape he does not make it pay. That which is biologically correct is also economically the most profitable. Our technologies must have as their primary objective the fertility of the soil and the stability of the plants and animals, and secondly, the objective of yield and profit.

In answer to the question, "Can we afford to conserve our landscape?" our answer would have to be, "Yes we can afford it". Not only can we afford it for economic and biological reasons but for recreational and aesthetic reasons. Man needs more than bread and butter; he needs certain emotional luxuries which are to be had from his landscape. It involves the question of man's respect for his civilization which has a spiritual and a material aspect.

I think we will have to admit that whatever man's nature must be, those qualities which are finest are profoundly affected by the physical things which appear to him. That means that he must have an ethical feeling of responsibility toward his landscape. He must assume responsibilities for conditions which help determine his behavior and that of his fellows. It is a way of life for city and country folk and when you try to persuade people to change it, it takes courage.

Great changes toward conservation thinking have come about in recent years. But the changes have not been enough. And now in time of war when emphasis is on destruction, the changes will be slower. For example, with the great emphasis on food production, when every ship load of food taken away carries with it tons of calcium, potassium, phosphorus, nitrogen, etc., all taken from the valuable topsoil in our

landscape, we must ask the questions: "Are we replacing what is taken away?" "What ship ever brings back our vital nutrients?"

Something tells me that we will keep on hurting Indiana landscape during this war. We certainly will if what is taken away is not replaced. The fields and woodlands will suffer some more for there is too great a demand for agricultural products and for lumber and too little emphasis placed on replacing nutrients. Indiana landscape, because of its richness, will have to furnish a lot. We beat down so much land during the first World War. We should have learned the lesson of the value of fertilization—to put back what should only be borrowed. If by hindsight we know some things are wrong we should not continue to do the same wrong. That is immoral. We may have to sacrifice a part of our landscape in order to win this war. But we should be most careful not to lose one bit more than is necessary. The pyramid of life should be kept as lofty as it is within our power to keep it. Indiana's landscape has great potentialities. We must heed the words from Proverbs. "There is a way which seemeth right unto a man, but the end thereof is the way of death". We must be sure to take the right way lest our destruction of the landscape lead to death.

The Call to Earth

What I am trying to say is that we should understand our environment and try to keep it in a healthy condition. Land is all of one body. We must keep our land so. We all live on, or from, the land. It is the source of our sustenance, our inspiration, our enjoyment. The life in every community sings a song. The discords of abuse, of course, have marred many parts of our landscapes. Lumbering, fire, drainage and agricultural enterprises have hurt the plants, animals, and the soils.

If the landscape is utilized, it should be well managed. The man who builds a machine may know the craftsman's satisfaction of a job well done but the man who manages the landscape becomes a partner with God in a creative act. We cannot build soils, plants, and animals. We can only preside at the mystery of their growth.

To understand but faintly what we are, what our machine-age civilization with its objectives of yield and profit has been doing to nature and her resources, one should study his environment. We must live with nature and be able to read the story she is trying to write for shortsighted, puny man. It is the everyday organisms and life's complexities, its vital interrelations, its unbelievable symbiotic systems that matter. In every community almost all problems are still unresolved. There are countless lovely things to make life a blessed privilege. But we must be alive and acutely sensitive to perceive and feel and appreciate them. They are to be had in the immediate landscape. There "like the spring choir of the marshes, rises the triumphant canticle of life's beauty". Understand it. Manage it. Live and enjoy it.

Indiana Plant Distribution Records, VII. 1946

This is a continuation of the series of annual reports intended to keep Deam's "Flora of Indiana" up to date. The present report comprises two sections, viz. "SPECIES," giving new county records with location of confirming specimens; and "NOMENCLATORIAL CHANGES" in which an attempt is made, within the limits and in the spirit of conservative taxonomy, to keep the "Flora" up to date in plant names.

Species

Genera are listed in the order used in the "Flora" and species are given in alphabetical order within the genera. Symbols following the county indicate the herbaria in which confirming specimens have been deposited. Species, varieties, and forms new for the state are given in bold face, and these together with name changes are followed by literature references. Cases of doubt whether a species, newly found within the state, will become a part of the state flora are preceded by an asterisk.

The specimens listed below have been collected by the following collectors: Arnold Arboretum (AA): Charles C. Deam; Ball State Teachers College (BS): Marion Rector; Butler University (B): F. K. Daily, W. A. Daily, Charles C. Deam, Ray C. Friesner, J. E. Potzger, John Wallace, and Ernest Warkenstein; Deam Herbarium (D): C. C. Deam, R. C. Friesner, J. E. Potzger; De Pauw University (DP): W. D. Gray, Winona H. Welch, and T. G. Yuncker; Earlham College (E): Mary Sue Dennis, H. Hudson, D. Keyser, L. J. King, M. S. Markle, Mark Marshall, Dorothy Riggin, and Jane Winslow; Gray Herbarium (G): R. C. Friesner, Ralph Kriebel; Huntington College (Hu): Fred Loew; University of Illinois (I): Agnes Chase, E. J. Hill; University of Michigan (Mi): R. C. Friesner; Missouri Botanical Garden (Mo): R. C. Friesner; New York Botanical Garden (NY): R. C. Friesner; U. S. National Herbarium (N): C. C. Deam, R. C. Friesner, J. E. Potzger; Wabash College (W): A. R. Bechtel.

The committee maintains a card file showing published distribution of each species within the state. Botanical workers needing such information may obtain distribution maps of any species recorded in the Flora, or subsequently added in these reports, by requesting same from the secretary of this committee.

The committee is grieved to be under the necessity of reporting, to those who may use this report and who may not have previous knowledge, the untimely death of one of its members, Mr. Ralph Kriebel. His dynamic personality and keen powers of taxonomic observation are greatly missed by those who were associated with him. His excellent herbarium

containing over 17,000 specimens has become the property of Purdue University.

Botrychium dissectum v. *obliquum*, Ripley (B). *Osmunda cinnamomea*, Fountain (B,D). *Woodsia obtusa*, Decatur (B). *Cystopteris fragilis* v. *protrusa*, Union (B). *Onoclea sensibilis*, Orange (B). *Athyrium angustum* v. *rubellum*, Orange (B), Ripley (B). *A. asplenioides*, Decatur (B), Orange (B). *Asplenium platyneuron*, Ripley (B). *Esquisetum arvense*, Decatur (B). *E. prealtum*, Clark (DP), Montgomery (B), Owen (B). **Lycopodium tristachyum** Pursh. Amer. Fern Jour. 36: 17-18. 1946. Lake (I), Porter (I), collected by Agnes Chase and E. J. Hill. *Selaginella apoda*, Cass (B).

Alisma subcordatum, Daviess (B), Decatur (B). *Bromus inermis*, Carroll (B), La Porte (B), Wells (D). *B. japonicus*, Carroll (B), De Kalb (B), La Porte (B), Ripley (B). *B. kalmii*, Noble (B). *B. secalinus*, Whitley (B). *B. tectorum*, Carroll (B). *Festuca rubra*, Porter (B, D). *Vulpia (Festuca) octoflora*, Cass (D), La Porte (B). *Poa compressa*, Jasper (B). *Poa languida*, Ripley (B), La Porte (D). *P. paludigena*, Porter (B). *P. sylvestris*, Carroll (B). *Eragrostis cilianensis*, Decatur (B), Huntington (Hu). *E. frankii*, Huntington (Hu), Lake (B), Posey (B, D). *E. hypnoides*, Huntington (Hu). *Uniola latifolia*, Daviess (B). *Dactylis glomerata*, Carroll (B).

Elymus villosus, Decatur (B), De Kalb (B, D). *E. virginicus*, Decatur (B), Ripley (B). *E. v.* v. *intermedius*, Posey (D). *Hystrix patula*, Ripley (B). *H. p.* v. *bigeloviana*, De Kalb (B, D). *Hordeum jubatum*, Huntington (Hu). *Lolium multiflorum*, La Porte (B). *Koleria cristata*, Allen (B). *Holcus lanatus*, La Porte (B). *Danthonia spicata*, Carroll (B). *Agrostis alba*, Ripley (B). *A. perennans*, Daviess (B). *A. scabra*, Lagrange (D). *Calamagrostis canadensis*, Carroll (B). *Phleum pratense*, Huntington (Hu), Whitley (B). **Muhlenbergia asperifolia** (Nees & Meyer) Parodi. Hitchcock, Grasses of U. S., p. 366. Lake (B, D, N). Collected by C. C. Deam and J. E. Potzger. *M. frondosa (M. mexicana* of Flora), Fulton (B, D). *M. f.* f. *commutata*, Fulton (B, D). *M. mexicana* f. *ambigua (M. foliosa* f. *ambigua* of Flora), Noble (B). *M. sylvatica*, Gibson (B). *M. tenuiflora*, Decatur (B). *Sporobolus clandestinus*, Daviess (B).

Milium effusum, Cass (B, D). *Cynodon dactylon*, Marion (B). *Digitaria ischaemum*, White (B). *Leersia oryzoides*, Posey (D). *Leptoloma cognatum*, Owen (B, D). *Paspalum pubiflorum* v. *glabrum*, Gibson (B). *Panicum addisonii*, Allen (B). *P. boreale*, Lagrange (B). *P. boscii*, Noble (B), Ripley (B). *P. clandestinus*, Huntington (D). *P. columbianum*, Jasper (B), Lake (B). *P. depauperatum*, Jasper (B). *P. dichotomiflorum*, White (B). *P. gattingeri*, Posey (B, D), White (B). *P. implicatum*, Allen (B), Cass (B, D). *P. leibergii*, Noble (B). *P. lindheimeri*, Ripley (B). *P. meridionale*, Lake (D). *P. oligosanthes*, Noble (B). *P. perlongum*, Noble (B). *P. stipitatum*, Posey (B). *P. subvillosum*, Lagrange (B). *P. tsugetorum*, Jasper (B). **P. tuckermanii**, Flora, p.

1030. Cass (D), Fulton (B, D), Marshall (D, N), Martin (D, N), Noble (D, N), Pulaski (D, N), Randolph (B).

Setaria faberii Herrm. Rhodora 48: 391. 1946. White (B, D, N). Collected by J. E. Potzger and C. C. Deam. *S. italica*, Daviess (B). *S. lutescens*, Huntington (Hu). *S. viridis*, Decatur (B), White (D). *Andropogon elliottii*, Spencer (B). *A. gerardi*, Ripley (B). *Sorghum vulgare* v. *drummondii*, Gibson (D).

Cyperus esculentus, Huntington (Hu). *Scirpus validus* v. *creber*, Huntington (D). *Carex bicknellii*, Huntington (Hu). *C. bromoides*, Cass (D). *C. lurida*, Huntington (Hu). *Arisaema dracontium*, Orange (B). *Juncus tenuis*, Cass (D). *Luzula echinata*, Clark (DP). *L. multiflora*, Fountain (B).

Veratrum woodii, Cass (B, D). *Uvularia grandiflora*, Whitley (B). *Allium tricoccum*, White (B, D). *Ornithogalum umbellatum*, Clark (DP). *Smilacina racemosa* v. *cylindrata*, Allen (B), Orange (B). *Maianthemum canadense*, Fountain (B, D). *Polygonatum biflorum*, Decatur (B), Huntington (Hu). *P. canaliculatum*, Allen (B). *Trillium flexipes*, Randolph (B), Whitley (B). *T. f.* f. *walpolei*, Henry (B), Wayne (E). *T. nivale*, Wayne (E). *T. recurvatum*, Wayne (E). *T. r.* f. *luteum*, Clark (DP). *T. sessile* f. *luteum*, Clark (DP). *Smilax herbacea*, Huntington (Hu).

Sisyrinchium angustifolium, Porter (D). *Dioscorea quaternata*, Decatur (B). *D. villosa*, Carroll (B), Ripley (B). *Habenaria dilatata*, La Porte (B, D). *H. lacera*, Ripley (B), Union (B). *H. peramoena*, Orange (B). *H. viridis* v. *bracteata*, Cass (B, D).

Populus grandidentata, Clay (B), Orange (B). *Salix amygdaloides*, Montgomery (W). *S. bebbiana*, Huntington (D, Hu). *Carya laciniosa*, Daviess (B). *C. ovalis* v. *obcordata*, Lagrange (D). *Ostrya virginiana* f. *glandulosa*, Decatur (B). *Alnus rugosa* v. *americana* (Regel) Fern. Rhodora 47: 333-361. 1945. *(A. incana* v. *americana*, of Flora). Porter (B, D, G). *A. r.* v. *a.* f. **hypomalaca** Fern. Rhodora 47: 333-361. Porter (B, D, G). Collected by C. C. Deam and R. C. Friesner. *A. r.* v. **typica** Fern. Porter (D, G). Collected by C. C. Deam. *A. r.* v. **typica** f. **emersoniana** Fern. Porter (G). Collected by D. C. Peattie.

Quercus bicolor, Daviess (B). X *Q. leana*, Cass (D), Daviess (B), Posey (B). *Q. palustris*, Daviess (B). X **Q. runcinata** Englemann *(Q. borealis* v. *maxima* x *Q. imbricaria)*. Trelease, Am. Oaks, p. 156, 193. Wells (AA, B, D). Collected by C. C. Deam. *Q. velutina*, Cass (D). *Ulmus americana* f. *alba*, Clay (B), Decatur (B), Delaware (B), Dubois (B), Fayette (B), Hamilton (B), Hancock (B), Harrison (B), Jay (B), Martin (B), Owen (B), Parke (B), Putnam (B), Randolph (B), Ripley (B), Shelby (B), Starke (B). *U. a.* f. *intercedens*, Wabash (B). *U. a.* f. *laevior*, Delaware (B), Howard (B), Kosciusko (B), Marion (B), Tipton (B), Wabash (B). *U. a. f. pendula*, Boone (B), Clay (B), Howard (B), Lawrence (B), Ohio (B), Switzerland (B). *Celtis laevigata*, Daviess (B). *Morus rubra*, Daviess (B). *Laportea canadensis*, Union (B).

Asarum canadense, Clark (DP). *Rumex crispus*, Huntington (Hu). *Polygonum aviculare*, Harrison (D). *P. coccineum*, Harrison (D). *P. convolvulus*, Howard (D), Wayne (E). *P. dumetorum*, Crawford (D), Randolph (B, D). *P. erectum*, Harrison (D). *P. hydropiper* v. *projectum*, Crawford (D), Porter (D). *P. hydropiperoides*, Decatur (B), Orange (B), Washington (D). *P. lapathifolium*, Harrison (D). *P. pennsylvanicum* v. *laevigatum*, Knox (B). *P. persicaria*, Crawford (D), Huntington (D). *P. punctatum*, Posey (D). *P. sagittatum*, Harrison (D). *P. scandens*, Harrison (D). *P. virginianum*, Crawford (D), Orange (D). *Chenopodium ambrosioides* ssp. *eu-ambrosioides* v. *typicum*, Daviess (B). *C. botrys*, Lake (B, D). *Corispermum hyssopifolium*, Newton (D). *Amaranthus graecizans (A. blitoides* of Flora), Porter (D). *A. retroflexus*, Posey (D). *Phytolacca americana*, Decatur (B).

Stellaria graminea, Putnam (DP). *Cerastium vulgatum* v. *hirsutum* f. *gladulosum*, Fountain (B). *Paronychia canadensis*, Carroll (B), Decatur (B). *Agrostemma githago*, Huntington (Hu). *Silene antirrhina*, St. Joseph (D). *S. cserei*, Lake (B). *S. dichotoma*, Elkhart (B, D). *S. noctiflora*, Huntington (Hu). *S. stellata*, Huntington (Hu). *Saponaria officinalis*, Decatur (B), Orange (B). *Aquilegia canadensis*, Allen (B). *A. c.* v. **coccinea** (Sm.) Munz. Gentes Herbarum 7: 120. 1946. Randolph (B). Collected by R. C. Friesner. *Anemonella thalictroides*, Bartholomew (B). *Hepatica acutiloba*, Clark (DP), Clay (B). *Clematis viorna*, Huntington (Hu). *C. virginiana*, Decatur (B). *Ranunculus abortivus*, Carroll (B). *R. longirostris*, Madison (B), Starke (B). *R. repens* v. *villosus*, Marion (B). *R. septentrionalis*, Fountain (B, D), Huntington (Hu).

Jeffersonia diphylla, Clark (DP). *Menispermum canadense*, Clark (DP). *Liriodendron tulipifera*, Daviess (B). *Sassafras albidum*, Daviess (B), Huntington (Hu), Orange (B). *S. a.* v. *molle*, Daviess (B), Decatur (B). *Sanguinaria canadensis*, Clark (DP). *Lepidium densiflorum*, Huntington (Hu). *L. virginicum*, Huntington (Hu). *Sisymbrium altissimum*, Union (B). *Brassica juncea*, Carroll (B). *B. kaber* v. *pinnatifida*, Allen (B), Carroll (B). *B. nigra*, Decatur (B). *Iodanthus pinnatifidus*, Clark (DP). *Nasturtium officinale*, Carroll (B), Posey (B). *Rorippa sessiliflora*, Carroll (B). *Cardamine pennsylvanica*, Fountain (B), *Dentaria laciniata*, Bartholomew (B). *Arabis dentata*, Clark (DP). *A. laevigata*, Union (B). *Conringia orientalis*, Carroll (B).

Heuchera americana v. *interior*, Carroll (B). *Mitella diphylla*, Clark (DP). *Grossularia cynosbati*, Lagrange (D). *Liquidambar styraciflua*, Crawford (D), Daviess (B), Orange (B). *Hammelis virginiana*, Ripley (B). *Physocarpus opulifolius*, Lake (B). *Aronia melanocarpa*, Allen (B), Fountain (D). *Crataegus punctata*, Huntington (Hu). *Fragaria vesca* f. *alba*, Putnam (DP). *Potentilla simplex* v. *typica*, Huntington (Hu). *Rosa carolina*, Carroll (B), Daviess (B). *R. setigera*, Union (B).

Gleditsia triacanthos f. *inermis*, Posey (D). *Medicago lupulina*, Orange (B), Ripley (B), Union (B). *Melilotus alba*, Orange (B), Union (B). *M. officinalis*, Union (B). *Trifolium hybridum*, Cass (D). *T. procumbens*, Clark (DP). *Robinia viscosa*, Lake (B, D), *Desmodium pauci-*

florum, Huntington (Hu). *Lespedeza nuttallii*, Harrison (D). *L. stipulacea*, Posey (D). *L. virginica* f. *deamii*, Harrison (D), Washington (D). *Lathyrus palustris* v. *myrtifolius*, Huntington (D). *Amphicarpa bracteata*, Delaware (BS). *Geranium pusillum*, St. Joseph (B, D). *Oxalis europea* v. *villicaulis*, Clark (DP). *O. stricta*, Clark (DP). *Linum virginianum*, Ripley (B). *Ptelea trifoliata*, Carroll (B).

Polygala ambigua, Ripley (B). *P. sanguinea*, Ripley (B). *P. senega*, Lake (B). *Euphorbia cyparissias*, Lake (B). *E. dentata*, Newton (D). *E. vermiculata*, Daviess (B). *Rhus glabra*, Orange (B). *R. radicans*, Daviess (B). *R. typhina*, Huntington (Hu). *Acer nigrum*, Franklin (B), Steuben (D). *A. rubrum*, Decatur (B). *Impatiens biflora*, Union (B). *Rhamnus lanceolata*, Huntington (Hu). *Tilia americana*, Union (B). *Hibiscus moscheutos*, Orange (B). *Hypericum mutilum*, Decatur (B), Ripley (B). *H. prolificum*, Huntington (D). *H. punctatum*, Huntington (Hu). *Viola eriocarpa* f. *leiocarpa*, Clark (DP). *V. papilionacea*, Carroll (B). *V. pedata* v. *linariloba*, Pulaski (B), White (B). *V. striata*, Clark (DP). *Ludwigia alternifolia* v. *typica*, Decatur (B). *Epilobium coloratum*, Ripley (B). *Oenothera laciniata*, Jasper (B). *Oe. tetragona* v. *longistipata*, Ripley (B). *Circaea quadrisulcata* v. *canadensis*, Decatur (B), Orange (B).

Aralia nudicaulis, Fountain (D). *Sanicula canadensis* v. *grandis*, Decatur (B). *S. c.* v. *typica*, Crawford (D). *S. marilandica*, Huntington (Hu). *Osmorhiza claytoni*, Cass (B). *O. longistylis*, Cass (B), Noble (B). *Angelica atropurpurea*, Carroll (B), Huntington (Hu). *Pastinaca sativa*, Union (B). *Nyssa sylvatica* v. *caroliniana*, Daviess (B), Ripley (B). *N. s.* v. *typica*, Decatur (B), Fountain (B, D). *Cornus drummondii*, Harrison (D), Union (B). *C. obliqua*, Huntington (D).

Gaultheria procumbens, Fountain (B, D). *Vaccinium vacillans*, Elkhart (D). *Lysimachia hybrida*, Ripley (B). *Dodecatheon meadia*, Newton (D). *Diospyros virginiana*, Daviess (B), Orange (B). *Fraxinus americana*, Franklin (B). *Sabatia angularis*, Ripley (B). **Centaurium pulchellum** (Sw.) Druce. Flora, p. 1080. Lake (B, D, G, Mi, Mo, NY). Collected by C. C. Deam and R. C. Friesner. *Gentiana crinita*, Steuben (D), White (B). *Vinca minor*, Clark (DP). *Apocynum cannabinum*, Huntington (D). *Asclepias incarnata*, Decatur (B), Ripley (B). *A. syriaca*, Washington (D). *A. tuberosa* v. *interior*, Huntington (D), Lake (B, D), Orange (B). *Ampelamus albidus*, Bartholomew (B). *Cuscuta campestris*, Wayne (E). *C. cephalanthi*, Wayne (E). *Convolvulus arvensis*, Wayne (E). *Ipomoea hederacea*, Decatur (B). *I. pandurata* v. *rubescens*, Wayne (E). *I. purpurea*, Wayne (E). *Quamlocit coccinea*, Crawford (D).

Phlox paniculata, Decatur (B). *Phacelia bipinnatifida*, Fountain (B, D). *P. purshii*, Morgan (B). *Myosotis verna*, Fountain (D). *Mertensia virginica*, Clark (DP). *Verbena hastata*, Decatur (B). *V. stricta*, Huntington (Hu). *V. urticaefolia* v. *leiocarpa*, Daviess (B), Orange (B), Steuben (D). *Trichostema dichotoma*, Lake (B, D). *Scutellaria lateriflora*, Decatur (B). *S. parvula*, White (D). *S. p.* v. *leonardi*, Jasper (B, D). *Agastache nepetoides*, Steuben (D). *Glecoma hederacea* v. *parviflora*,

Clark (DP). *Prunella vulgaris* v. *lanceolata*, Orange (B), Union (B). *Synandra hispidula*, Franklin (B). *Lamium amplexicaule*, Clark (DP). *L. purpureum*, Clinton (B). *Leonurus cardiaca*, Huntington (Hu). *Stachys tenuifolia* v. *typica*, Decatur (B). *Blephilia ciliata*, Huntington (D, Hu). *B. hirsuta*, Delaware (BS). *Hedeoma pulegioides*, Union (B). *Pycnanthemum flexuosum*, Ripley (B). **Lycopus asper** Greene. Britton and Brown, Ill. Flora 3: 148. Lake (B, D, Mi, Mo, N, NY). Collected by C. C. Deam and R. C. Friesner. *L. virginicus*, Daviess (B).

Physalis heterophylla, Clay (B, D). *P. pubescens*, Knox (D). *Verbascum blattaria*, Orange (B). *V. thapsus*, Orange (B). *Linaria vulgaris*, Huntington (Hu). *Chaenorrhinum minus*, Huntington (Hu), Orange (B). *Scrophularia marilandica*, Decatur (B). *Penstemon calycosus*, Union (B). *P. hirsutus*, Huntington (Hu). *Veronica arvensis*, Carroll (B), Elkhart (D). *V. peregrina* v. *typica*, Fountain (B). *Dasistoma macrophylla*, Delaware (BS). *Melampyrum lineare* v. *latifolium*, La Porte (D). **Pedicularis canadensis** v. **dobsii** Fern. Rhodora 48: 59-60. 1946. Porter (B, D), Wells (D). Collected by C. C. Deam. *Campsis radicans*, Ripley (B). *Orobanche uniflora* v. *typica*, Cass (B), Lake (B). *Ruellia strepens*, Union (B). *Phryma leptostachya*, Orange (B).

Plantago major, Lake (B, D). *P. purshii*, Jasper (B, D). *P. virginica*, Cass (B). *Cephalanthus occidentalis*, Ripley (B). *Galium circaezans*, Clark (DP). *G. c.* v. *hypomalacum*, Delaware (BS). *G. obtusum*, Decatur (B), Huntington (Hu), Lake (B), Orange (B), Ripley (B). *G. tinctorium*, Lagrange (D). *Viburnum rufidulum*, Daviess (B). *Sambucus canadensis*, Orange (B). *Lonicera japonica*, Orange (B). *Valerianella chenopodifolia*, La Porte (B, D). See also Rhodora 48: 96. *V. intermedia*, Huntington (Hu), Montgomery (D). *Campanula aparinoides*, Steuben (D). *Specularia perfoliata*, St. Joseph (D). *Lobelia cardinalis*, Bartholomew (B), Decatur (B), Huntington (Hu).

Eupatorium altissimum, Clay (B, D). *E. fistulosum*, Ripley (B). *E. purpureum*, Ripley (B). *E. serotinum*, Decatur (B). *Grindelia squarrosa*, Marion (D). *Solidago altissima*, Wayne (E). *S. caesia*, Clay (B), Daviess (B). *S. canadensis*, Huntington (Hu). *S. gigantea*, Wayne (E). *S. g.* v. *leiophylla*, Decatur (B), Wayne (E). *S. juncea*, Decatur (B), Ripley (B). *S. latifolia*, Wayne (E). *S. nemoralis* v. *typica*, Wayne (E). *S. patula*, White (D, B). *S. ulmifolia*, Daviess (B), Ripley (B). Aster **angustus** (Lindl.) T. & G. Gray Man. 7ed., p. 816. Lake (B, D, G, Mi, Mo, N, NY). Collected by C. C. Deam and R. C. Friesner. *A. novae-angliae*, Greene (B). *A. pilosus*, Daviess (B), Lake (B). *A. puniceus*, Huntington (Hu). *A. sagittaefolius*, Ripley (B). *Erigeron annuus*, Orange (B), Union (B). *E. strigosus*, Huntington (Hu), Union (B). *Antennaria fallax* v. *calophylla*, Fountain (B, D). *Gnaphalium purpureum*, Cass (D), Union (B). *Silphium terebinthinaceum*, Howard (B). *Ambrosia bidentata*, Orange (B, D). *A. trifida*, Huntington (Hu). *Heliopsis helianthoides*, Daviess (B). *Eclipta prostrata*, Huntington (Hu).

Rudbeckia hirta, Huntington (D). *Brauneria purpurea*, White (D). *Helianthus annuus*, Marion (B, D). *H. giganteus*, Huntinton (Hu). H.

silphioides Nutt. Rhodora 48: 77-79. 1946. Lawrence (G, K). Collected by Ralph Kriebel: his No. 3965. *H. strumosus*, Washington (D). *H. tuberosus*, Crawford (D), Washington (D). *Coreopsis tripteris*, Lake (D). *Bidens bipinnata*, Huntington (Hu). *B. cernua*, Huntington (Hu). *B. comosa*, Ripley (B). *Hymenopappus carolinensis*, Newton (B, D). *Achillea millefolium*, Orange (B). *Chrysanthemum leucanthemum* v. *pinnatifidum*, Cass (B, D), Huntington (Hu). *Erechtites hieracifolia*, Ripley (B). *Anthemis arvensis*, Marion (B). *A. cotula*, Orange (B). *Cirsium discolor*, Ripley (B). *C. vulgare*, Huntington (Hu). **Centaurea maculosa*, Porter (G). Rhodora 48: 391. *Krigia biflora*, Union (B). *Tragopogon dubius*, De Kalb (D), Kosciusko (B), St. Joseph (D), Steuben (D). *T. porrifolius*, Huntington (Hu). *Taraxacum palstre* v. *vulgare*, Clark (DP). *Sonchus oleraceus*, Huntington (Hu). *Lactuca biennis*, Harrison (D). *L. b.* f. *integrifolia*, Ripley (B). *L. canadensis* v. *latifolia*, Union (B). *L. c.* v. *longifolia*, Orange (B). *L. scariola* v. *integrata*, Delaware (BS). *Prenanthes altissima*, Delaware (BS). *P. aspera*, Washington (D).

Nomenclatorial Changes

The following changes in names of Indiana plants are considered by the committee to be likely of acceptance by taxonomists generally. Other name changes have recently appeared in the literature but are temporarily withheld from this list awaiting further evidence of their merit.

Alisma plantago-aquatica var. brevipes (Greene) Samuelsson to
A. triviale Pursh
Rhodora 48:86-88. 1946.

Stenanthium robustum wats. to
S. gamineum var. **robustum** (Wats.) Fern.
Rhodora 48:148-152. 1946.

Sisyrinchium angustifolium Mill. to
S. montanum Greene
Rhodora 48:152-160. 1946.

Sisyrinchium graminoides bickn. to
S. angustifolium Mill.
Rhodora 48:152-160. 1946.

Cypripedium parviflorum salisb. to
C. calceolus var. **parviflorum** (Salisb.) Fern.
Rhodora 48:4. 1946

Spiranthes beckii Lindl. to
S. tuberosa Raf.
Rhodora 48:5. 1946

Spiranthes ovalis Lindl. to
S. montana Raf.
Rhodora 48:5. 1946

Corallorrhiza trifida Chatelain to
Corallorhiza trifida var. **verna** (Nutt.) Fern.
Rhodora 48:197. 1946

Salix cordata Muhl. to
S. rigida Muhl.
Rhodora 48:31-48. 1946

Salix discolor var. latifolia Anderss. to
S. eriocephala Michx.
Rhodora 48:27-28. 1946

Salix longipes Shuttlew. to
S. caroliniana Michx.
Rhodora 48:28-31. 1946

Salix petiolaris J. E. Smith (Sensu Flora) to
S. gracilis var. **textoris** Fern.
Rhodora 48:46-48. 1946

Alnus incana var. americana Regel to
A. rugosa var. **americana** (Regel) Fern.
A. rugosa var. **americana f. hypomalaca** Fern.
A. rugosa var. **typica** H. Winkl.
A. rugosa var. **typica f. emersoniana** Fern.
Rhodora 47:333-361. 1945

Alnus rugosa (Ehrh). Spreng. to
A. serrulata var. **vulgaris** Spach.
Rhodora 47:333-361. 1945

Urtica procera Muhl. to
U. dioica var. **procera** (Muhl.) Wedd.
Amer. Midland Nat. 35:773-778. 1946

Arabis dentata T. & G. to
A. perstellata var. **shortii** Fern.
Rhodora 48:208. 1946

Acerates viridiflora (Raf.) Eaton to
Asclepias viridiflora Raf.
Rhodora 48: 208-209. 1946

Kuhnia eupatorioides L. to
K. eupatorioides var. **pyramidalis** Raf.
Wrightia 1:132-136. 1945

Helianthus rigidus (Cass.) Desf. to
H. laetiflorus var. **rigidus** (Cass.) Fern.
Rhodora 48:79-80. 1946

Helianthus rigidus f. flavus Deam to
H. laetiflorus Pers.
Rhodora 48:79-80; 112. 1946

State Flora Committee:
CHARLES C. DEAM, *Chairman*
T. G. YUNCKER
R. C. FRIESNER, *Secretary*

CHEMISTRY

Chairman: Ed. F. Degering, Purdue University

Dr. Alvin Strickler, Evansville College, was elected chairman of the section for 1947.

ABSTRACTS

Sidelights on research. F. J. Allen, Purdue University.—The intent of this paper was to set forth some of the personal items met with in research which seldom get into the actual research report and which might be hinted at under such captions as: discouraging remarks by colleagues, encouragement from industry, interesting people encountered, experiments which failed, etc. The paper was based on the author's research on Krypton and Xenon.

Stabilization of the color of turquoise. Frank B. Wade, Shortridge High School.—Making use of the fact that the cuprammonia complexion $Cu(NH_3)_4$ adsorbs strongly to silica gel, the porous types of turquoise which tend to fade or turn green may be treated with sodium silicate (water glass) for a greater or lesser period depending on the degree of porosity. The stones may then be treated with hydrocloric acid to precipitate silica gel within the pores of the stone and finally soaked in a concentrated solution of cuprammonia sulphate which causes the gel to adsorb the complexion and give the stone a color which closely resembles the choicer colors in fine turquoise.

The rough material should be cut to the finished shape, "sanded", ready for the polishing operation, then treated as above and finally dried and polished. The product will wear fairly well for a year or more.

The Preparation of Derivatives of Stearophenone and Related Compounds

JOHN M. DAVIS* with ED. F. DEGERING, Purdue University

Many investigators have shown that fatty-acid molecules can be tailored to meet requirements as surface-active agents, as auto-oxidation inhibitors or stabilizers, and as therapeutic agents.

The oldest surface-active agent is soap, whether made by saponification of fats with alkali or in more complex forms such as neutralization of fatty-acids with amines.

The addition of a hydrocarbon side chain and a sodium sulfonate group to an aromatic nucleus forms alkyl aryl sulfonates. In such compounds, one has a structure related to soap by a series of easy transitions. Benzene sulfonic acid shows some surface-active properties, toluenesulfonic acid more. Practically a longer side chain than the methyl radical is desirable to produce an adequate hydrocarbon character. The simplest form is a benzene derivative such as sodium kerylbenzenesulfonate, keryl meaning an aliphatic radical of the order of magnitude of that of the kerosene fraction.

This paper presents the results of a study in the preparation of compounds such as *n*-octadecylbenzene and *p*-chlorooctadecylbenzene which may be used as intermediates in the production of surface-active agents like sodium octadecylbenzenesulfonate and trimethyloctadecylbenzeneammonium chloride.

The procedures used in the synthesis of the halogenated octadecylbenzenes are illustrated by the equations

1. $CH_3(CH_2)_{16}CH_2Cl + C_6H_5X \rightarrow CH_3(CH_2)_{16}CH_2.C_6H_4.X + HCl$, or
2. a. $CH_3(CH_2)_{16}.CO.Cl + C_6H_5X \rightarrow CH_3(CH_2)_{16}.CO.C_6H_4.X + HCl$, and
   b. $CH_3(CH_2)_{16}COC_6H_5X + 2H_2/(Zn/Hg/HCl) \rightarrow CH_3(CH_2)_{17}C_6H_4.X + H_2O$

It was found that the chlorooctadecylbenzenes prepared by the Friedel-Crafts reaction of *n*-octadecyl bromide with chlorobenzene do not have the same distilling range or melting point as the chlorooctadecylbenzenes prepared by the modified Clemenson reduction of the chlorostearophenones. This has led to the belief that the Friedl-Crafts reaction of *n*-octadecyl bromide with a halogenated benzene nucleus results in a

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secondary octadecyl radical being attached to the benzene nucleus instead of a *n*-octadecyl radical.

Ammonolysis of *p*-chlorooctadecylbenzene was carried out, using pressure, heat, and a catalyst, to form *p*-aminooctadecylbenzene. The amine is very unreactive, even to the formation of a hydrochloride.

Several derivatives of the various ketones synthesized, were made in order to characterize the individual ketones.

Experimental

A. Preparation of chlorooctadecylbenzene by the Friedel-Crafts reaction of *n*-octadecyl bromide with chlorobenzene

The *n*-octadecyl bromide was prepared by bubbling dry hydrogen bromide through molten *n*-octadecyl alcohol.

The *n*-octadecyl bromide so prepared was reacted with excess chlorobenzene in the presence of anhydrous aluminum chloride. Upon vacuum distillation of the resultant oil two separate fractions were identified. A fraction distilling at 205° C. (1 mm.) was proved to be *p*-chlorobenzoic acid. In a like manner a fraction distilling at 195° C. (1 mm.) was proved to be *o*-chlorooctadecylbenzene.

The theoretical molecular weight for both compounds is 365. The molecular weight for the fraction distilling at 205° C. (1 mm.) was found to be 360 and for the fraction distilling at 195° C. (1 mm.) 356.

B. Preparation of *p*-chlorooctadecylbenzene by the reduction of *n*-heptadecyl *p*-chlorophenyl ketone

The *n*-heptadecyl *p*-chlorophenyl ketone was prepared in the same manner as Claus and Hafelin[1] prepared *n*-heptadecyl phenyl ketone. The ketone was reduced to *p*-chloro-*n*-octadecylbenzene using the modified Clemenson method as suggested by Adams[2]. Upon vacuum distillation of the resultant oil a fraction distilling at 220-225° C. (1 mm.) and melting at 42-43° C. was proved to be *p*-chloro-*n*-octadecylbenzene.

The theoretical molecular weight is 365. The molecular weight as determined was found to be 359.

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TABLE I.—Compounds Prepared

Compound	Dist. Range (1 mm.)	M. p., °C.
n-Octadecylbenzene	195-205°C. (4 mm.)	35-36
n-Heptadecyl Phenyl Ketone		63.5-64.5
n-Heptadecyl *o*-Chlorophenyl Ketone	230-235	63
n-Heptadecyl *p*-Chlorophenyl Ketone	250-260	76
o-Chloro-*n*-octadecylbenzene	210-215	36-37
p-Chloro-*n*-octadecylbenzene	220-225	42-43
p-Amino-*n*-octadecylbenzene	245-251	
	Detr. %N=4.01	Theor. %N=4.06
p-Bromo-sec.-octadecylbenzene	235	
o-Bromo-sec.-octadecylbenzene	195	
n-Heptadecyl *p*-Chlorophenyl Ketone		94
n-Heptadecyl *o*-Chlorophenyl Ketone		85
n-Heptadecyl *p*-Chlorophenol Ketoxime		42
n-Heptadecyl *p*-Chlorophenyl Ketone Semicarbazone		85
n-Heptadecyl *o*-Chlorophenyl Ketone Semicarbazone		66

Summary

The chlorooctadecylbenzenes prepared by the Friedel-Crafts reaction of *n*-octadecyl bromide with chlorobenzene do not have the same distilling range or melting points as the chlorooctadecylbenzenes prepared by the modified Clemenson reduction of the chlorostearophenones. This has lead to the belief that the Friedel-Crafts reaction of *n*-octadecyl bromide with a halogenated benzene nucleus results in a secondary octadecyl radical being attached to the benzene nucleus instead of a *n*-octadecyl radical.

Ammonolysis of *p*-chlorooctadecylbenzene was carried out using pressure and heat, to form *p*-aminooctadecylbenzene.

Several deriviatives of the various ketones were made in order to characterize the individual ketones.

Recent Advances in Fluorine Chemistry

A. A. Alberts, Z. D. Welch and E. T. McBee, Purdue University

In 1931, Freon 12 was introduced to the refrigeration industry as the "ideal" refrigerant (1). This refrigerant—a fluorine-containing organic compound, dichlorodifluoromethane—is characterized by its chemical inertness, thermal stability, and nontoxicity. In the decade which followed, the demand for this material increased rapidly. Also, in the same period there was an increase in interest in fluorine-containing organic compounds. This increase in interest can be attributed to the many unusual properties possessed by fluorine-containing compounds, e.g. the fluorine atoms in organic compounds containing two fluorine atoms attached to a carbon atom are very firmly held. This enhanced stability is transmitted to a lesser degree to substituents on adjacent carbon atoms. Hence, it is not surprising to find that fluorine compounds have potential uses as plastics, lubricants, tanning agents, heat-transfer agents, hydraulic fluids, dielectrics, and pharmaceuticals (2).

A symposium on fluorine chemistry was a part of the 110th meeting of the American Chemical Society held at Chicago, September, 1946. Many of the topics discussed in this paper were presented at this symposium.

Three general methods have been used for the preparation of fluorine-containing compounds; namely, (1) direct fluorination, (2) replacement of halogen in an organic compound by the use of inorganic fluorides, and (3) addition of hydrogen fluoride to carbon-carbon multiple bonds. However, with a few exceptions these procedures are not generally applicable to the preparation of fluorocarbons, i.e. compounds containing only fluorine and carbon. Consequently, new methods for the preparation of such compounds were sought when it was demonstrated that fluorocarbons were needed in large quantities by the Manhattan Project. As a result of this research, a fourth method was made available for the preparation of fluorine compounds. This method is the reaction of an organic compound with certain metal fluorides, e.g., cobalt (III) fluoride, silver (II) fluoride, magnanese (III) fluoride, cerium (IV) fluoride, and lead (IV) fluoride. These metal fluorides are most conveniently prepared by reaction of the lower valent fluoride with elemental fluorine. As a matter of fact, with the exception of lead (IV) fluoride, the only known method of preparation involves the use of elemental fluorine.

The large-scale production of fluorine can be acclaimed as a real achievement inasmuch as the production of fluorine, prior to 1942, was costly and the amount produced insignificant, less than 25 pounds per day. This development is particularly noteworthy when one considers the chemical reactivity and the corrosiveness of fluorine. The production of

fluorine depends upon the electrolytic decomposition of hydrogen fluoride. One type of cell uses 2000 amperes at about 10 volts (3) to which a small amount of lithium fluoride, less than 1%, is added to the electrolyte, KF.2HF. The anode may be of carbon or nickel and the cathode of iron. By maintaining the hydrogen fluoride concentration at 38 to 38.5% the cells have run up to 1½ years with no major shut down.

The development of cells for large-scale production was carried out by the Harshaw Chemical Company, E. I. duPont de Nemours and Co., and the Hooker Electrochemical Company. Laboratory cells were also developed by Johns Hopkins University, Massachusetts Institute of Technology and Pennsylvania Salt Mfg. Company.

Fluorine has been successfully delivered into storage tanks at 30 pounds per square inch by oil-operated, diaphragm pumps transmitting pulsations hydraulically to a second pumping head containing a fluorohydrocarbon (3). It has also been successfully compressed and stored in cylinders of copper, nickel or steel at pressures as high as 300 pounds per square inch (4, 5).

A process for the production of an equally satisfactory coolant was developed by McBee and his associates at Purdue University (9). *n*-Heptane was chlorinated photochemically in the liquid phase to a chlorine content of about 83%. This mixture of polychloroheptanes was converted to polychloropolyfluoroheptenes by fluorination with hydrogen fluoride at 125° C. in the presence of an equal weight of antimony (V) chloride. The product was removed from the reactor by distillation leaving the antimony residues which can be reused effectively in subsequent fluorination if anhydrous conditions are maintained.

The polychloropolyfluoroheptene (average formula $C_7H_xCl_3F_9$) was further fluorinated in the vapor phase by either cobalt (III) fluoride or silver (II) fluoride to perfluoroheptane and monochloroperfluoroheptane. It was found that silver (II) fluoride is more effective in the replacement of chlorine atoms by fluorine than cobalt (III) fluoride. Perfluoroheptane prepared in this manner was contaminated with chlorine containing substances. These contaminants could be removed by azeotropic distillation with methyl ethyl ketone producing pure perfluoroheptane (10).

In addition to the coolant mentioned previously, other fluorine-containing materials were needed for the Manhattan project. These materials were characterized by their low vapor pressure as well as their chemical inertness.

Terphenyls and open chain hydrocarbons containing from sixteen to twenty-one carbon atoms per molecule were fluorinated in the vapor-phase with cobalt (III) fluoride at 300° C. Compounds whose general formula may be represented by the formula $-(CF_2)_x-$ were formed. Silver (II) fluoride also proved satisfactory in this fluorination. However, when silver (II) fluoride was used, the reaction was conducted in the liquid phase. (11, 12, 13).

A tetrafluoroethylene polymer, known as Teflon and marketed by DuPont, has many uses owing to its nonreactivity to chemicals, including fluorine (14). Tetrafluoroethylene is prepared by the thermal decomposition of chlorodifluoromethane (15). In addition to the desired

tetrafluoroethylene, a series of new compounds having the general formula $H(CF_2)_nCl$ is obtained, accompanied by a small quantity of highly toxic substances. The identity of these latter materials has not been established.

Another fluorine containing polymer was prepared by the polymerization of perfluorovinyl chloride (16, 17). The products isolated ranged from colorless, stable oils to solid resins. By further fluorination of these oils with cobalt (III) fluoride the thermal stability of the oils was increased.

Simons and McArthur (18) have reported that hydrogen fluoride is a suitable media for the liquid-phase oxidation with molecular oxygen. The products formed are not those usually expected. Benzene is converted to phenol; toluene, to cresol. In the complete combustion of certain compounds, carbon is formed rather than carbon monoxide and carbon dioxide.

Fluorine containing organic acids can be prepared by the permanganate oxidation of fluorine containing olefins (19, 20). For example, trifluoroacetic acid is prepared by the oxidation of 3,3,3-trifluoro-1,1,2-trichloropropene. Perfluoroglutaric and perfluoroadipic acids are prepared by the oxidation of 1,2-diochloroperfluorocyclopentene and 1,2-dichlorocyclohexene respectively. These fluorine containing acids are relatively strong and water soluble.

The use of hexafluoroacetylacetonates as a reagent for the separation of the rare earth elements by distillation has been reported by Quill (21).

The action of fluorine on molten sulfur results in the formation of sulfur (VI) fluoride. This material is arousing much interest and finds use as a gaseous dielectric in high voltage generators (22).

The energy released in the exothermic reaction of hydrogen and fluorine has been utilized in a torch that is capable of producing a temperature over 6000° F. By the use of Hydrogen-Fluorine torch, copper can be welded with ease. Nickel, Monel, and steel were welded with equal facility, but aluminum resisted efforts of being welded (23).

Undoubtedly a great many discoveries of the recent years are as yet unreported because of censorship regulations, either for national security or because of patent security. Nonetheless, the importance of fluorine containing substances has been established and the future of fluorine chemistry is most promising.

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Hydrolysis Rates of Unsaturated Esters in Alkaline Emulsion Systems of the GR-S Type*

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One of the main difficulties in employing unsaturated esters of the acrylate type in the preparation of synthetic rubber arises from the tendency of such esters to hydrolyze in the common alkaline emulsion system. In the copolymerization of butadiene and styrene the pH of the system does not change to any large degree during the reaction. However, when methyl acrylate is present, the pH of the system drops considerably as the copolymerization proceeds. This may lead to a decrease in the rate of polymerization and a change in the properties of the polymer, usually in an undesirable manner. While these results have been established qualitatively by various workers (2, 7), little of a quantitative nature is known concerning the rates or degrees of hydrolysis of acrylate esters in alkaline emulsions. In this work a study has been made of these hydrolysis rates, and certain factors governing them have been determined.

Much literature is available concerning the rates of hydrolysis of esters in alkaline systems (1, 4, 5, 6), but in all cases the systems have been simple. Usually the ester is in solution and the alkali used is sodium or potassium hydroxde. In these cases the amount of hydrolysis is frequently determined by withdrawing a sample and titrating it with standard acid. This technique is not easily adaptable to a complex emulsion system containing ingredients which may interfere with indicator end points. Therefore it was decided to prepare an emulsion as used in ploymerizations and to follow the pH of the system over a period of time, with a glass electrode pH meter.

By plotting the pH of the system against reaction time, the rate and degree of hydrolysis can be determined. The relationship between structure of monomer and hydrolysis rate can also be determined, and the results used to select satisfactory esters and emulsion systems for copolymerizations.

Experimental Procedure

Five acrylate and methacrylate esters which are readily available commercially were selected for study. Methyl acrylate, ethyl acrylate and butyl methacrylate were obtained from the Rohm and Hass Company.

* Abstracted from a thesis submitted by E. Jack Kahler to the faculty of Purdue University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1945.

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Methyl and ethyl methacrylate were obtained from E. I. du Pont de Nemours and Company.

Two different types of emulsion recipes were employed; one, the "unactivated" system commonly used in the production of GR-S, the other, the "activated" system frequently used in laboratory polymerization studies. The recipes for these two systems are presented in Table I.

TABLE I.

Unactivated	POLYMERIZATION RECIPES	Activated
180 ml.	Water	190 ml.
5 g.	Soap	3 g.
0.5 g.	Potassium persulfate	1 g.
0.65 g.	O.E.I.	0.65 g.
	Potassium ferricyanide	0.15 g.
	Sodium hydroxide (5% soln.)	10 ml.
25 g.	Comonomer	25 g.
75 g.	Butadiene*	75 g.

The reaction vessel consists of a three-neck, round bottom, 500 ml. flask equipped with stirrer and condenser. The third neck is stoppered and is used for withdrawal of samples. The flask is heated by an electric heating mantle equipped with a variable transformer for temperature control.

The soap is dissolved in the water at 50° C., and after the solution has cooled to 35-40° C. the potassium persulfate and ferricyanide are added. The soap and sodium hydroxide solutions are then added to the reactor and the stirrer started. O.E.I. is added from a calibrated micro-dropper at this time. The reaction mixture is then brought to 40° C. (the reaction temperature) before the monomer is introduced.

It is advisable to take a zero time sample and to determine its pH. With the "unactivated" system a value of 10.2 is obtained for all such zero time samples. The ester is added and samples are taken at time intervals of 15-30 minutes for the first 3 hours and then at intervals of 1-3 hours for the remaining time.

A 10 ml. sample, taken by means of a suction pipette and water aspirator, is sufficient for a satisfactory pH reading. Part of the sample is used in rinsing the glass cup of the pH meter, and the remainder for the pH determination. If there is any of the sample unused it can be returned to the reactor.

A Coleman pH meter with a glass electrode was used throughout the entire hydrolysis study. This unit was modified for the titration of the "unactivated" and the "activated" systems. The glass electrode was immersed directly into the solution being titrated, and the calomel cell was connected to the soap emulsion by means of a saturated potassium chloride bridge.

* Butadiene was ordinarily omitted from the recipes to allow the use of simple laboratory equipment.

Discussion

pH Versus Reaction Time.

Unactivated System. Probably the most familiar formula for the preparation of butadiene-styrene copolymers is the one used in the production of GR-S. This is well known for its simplicity and general utility. Table I shows the amounts of ingredients based on 100 g. of monomers for a similar recipe which is referred to as an "unactivated" system. In this system the butadiene was omitted to eliminate the need for pressure equipment and to simplify the sampling procedure. The presence of butadiene would have only a minor effect on the resulting pH data by decreasing somewhat the amount of ester dissolved in the water phase. Therefore, the rates of ester hydrolysis would be slightly larger in the absence of butadiene than in its presence. This effect would not modify seriously any correlation obtained between the structure of an acrylate ester and its rate of hydrolysis. Proof of this was obtained directly by comparing the pH of an emulsion containing butadiene with the pH of a system not containing butadiene. After several hours of reaction the pH values of the two systems were identical as determined.

The pH data resulting from the rate studies of these five esters in the "unactivated" system are shown in figure 1. These data indicate

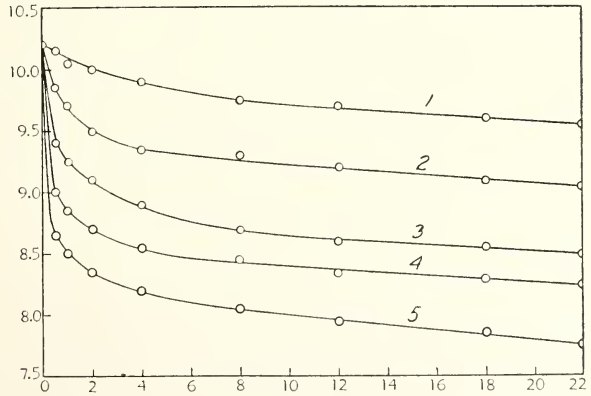

Fig. 1. pH Versus Hours of Reaction Time for Esters in the "Unactivated" System. Curve 1. Butyl methacrylate; Curve 2. Ethyl methacrylate; Curve 3. Methyl methacrylate; Curve 4. Ethyl acrylate; Curve 5. Methyl acrylate.

that the largest change in pH occurs during the first 2-4 hour period, after which the rate of pH change becomes small and nearly constant for all of the esters studied. It is evident that systems containing esters of low molecular weight have larger initial drops in pH than those containing esters of high molecular weight. The explanation for the change in pH becoming nearly constant for all esters after the initial drop in pH could be either a buffering action caused by the organic salts formed during hydrolysis or an actual slowing down of the hydrolysis. Additional studies relative to this effect will be discussed in a subsequent section.

Activated System. Although an "unactivated" system is very useful in exploratory work, other types of polymerization recipes are often utilized to obtain faster reaction rates and also to obtain improved products. These are often referred to as "activated" systems. The second system studied falls in this class. The chief difference between the two recipes other than slight changes in the amount of water, soap, and persulfate is the addition of potassium ferricyanide and sodium hydroxide. Table I shows the amounts of ingredients based on 100 g. of monomers for such a recipe. As in the hydrolysis study of the "unactivated" system, the butadiene was omitted.

The pH data resulting from studies of methyl acrylate, methyl methacrylate, and butyl methacrylate in the "activated" system are

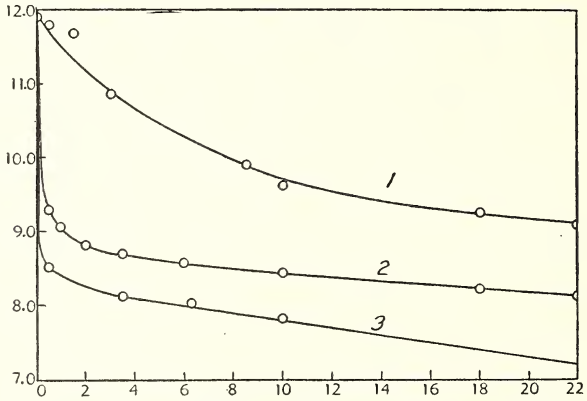

Fig. 2. pH Versus Hours of Reaction Time for Esters in the "Activated" System. Curve 1. Butyl methacrylate; Curve 2. Methyl methacrylate; Curve 3. Methyl acrylate.

shown in figure 2. These data show the same immediate drop in pH and leveling off to a constant pH change as was noted for the esters in the "unactivated" system. The most interesting result is that although the initial pH lowering is much larger, the pH of the system after 2-4 hours is only slightly lower than for the same ester in the "unactivated" system. This indicates that the excess sodium hydroxide is neutralized very quickly by the hydrolysis products of the ester, and that after this reaction has taken place the two systems are comparable in pH.

Titration of Emulsion Systems with Acetic Acid.

There are two possible explanations for the change in the rate of pH drop with time. First, the hydrolysis could have continued at its initial rate without an accompanying change of pH because of a buffering action by the organic salts formed. Second, the hydrolysis could have actually slowed down because the lower pH of the system no longer promoted rapid hydrolysis.

It was decided to determine the extent of the buffering action of the organic salts on the pH change by directly titrating the emulsion

systems with acetic acid, which is comparable in strength to acrylic and methacrylic acids. If buffering action were appreciable the pH of the system titrated would level off in the same range (pH of 7.5-9.5) as in the ester hydrolysis studies. If such an action did not occur, the pH of the titrated system would continue to drop as acid was added until a pH of 4-5 was attained.

Figure 3 and 4 were obtained by plotting the data obtained on titrating each system with acetic acid of known strength and following the pH. It is evident from these curves that the pH continues to decline as acid is added to the system and that no buffering action occurs within the pH range of 7.5-9.5. Therefore, the change of rate of the pH lowering in the original studies of the acrylate esters in the "unactivated" and

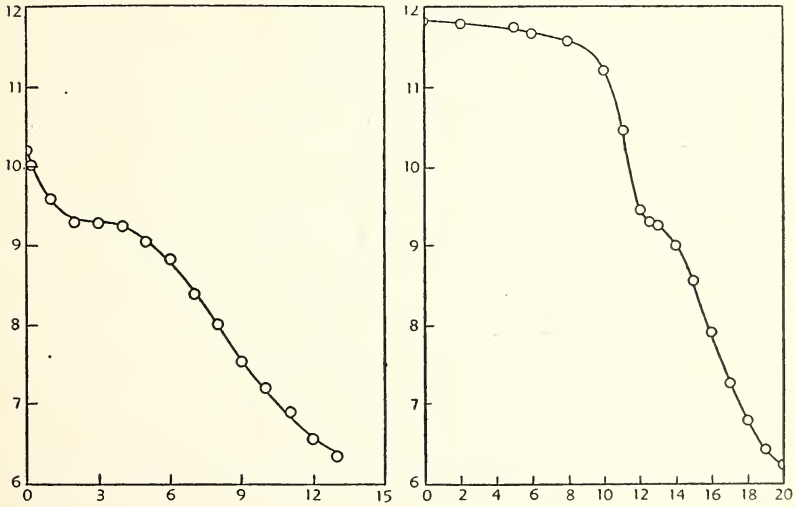

Fig. 3. Titration of the "Unactivated" System with 1 N Acetic Acid.
Fig. 4. Titration of the "Activated" System with 1 N Acetic Acid.

"activated" systems must be due to an actual slowing down of the rates of hydrolysis.

Development of Rate Curves.

Acetic acid was used in the titration of the emulsion systems because of its ease of handling as compared to acrylic or methacrylic acid. Acetic and acrylic acids have ionization constants of the same order of magnitude (1.8×10^{-5} and 5.5×10^{-5} respectively) (3), and because of this it can be assumed that if acrylic acid had been used in the titration of the "unactivated" and "activated" systems, approximately the same curves would have been obtained.

By combining the data obtained in the pH studies of esters in the two systems with the data obtained in the titration of the same systems,

a series of curves can be drawn which show approximately the amount of hydrolysis after various periods of reaction. This can be explained in the following manner. The first series of studies give data showing the relationship of pH with time of reaction. The second series of studies give data showing the relationship of pH with the amount of acid used in the titration. As the ester is hydrolyzed, acid and alcohol are produced, and the liberated acid causes a lowering of pH. Therefore, it is possible to obtain a relationship between the amount of acid used in the titration and the time of reaction. This is the same as the relationship between the amount of acid liberated by hydrolysis and the reaction time, or the actual rate of hydrolysis curve.

The specific example of ethyl acrylate in the "unactivated" system will clarify this relationship. First, (Figure 1) the pH after three hours of reaction is found to be 8.6. Second, (Figure 3) it is seen that 6.5 ml.

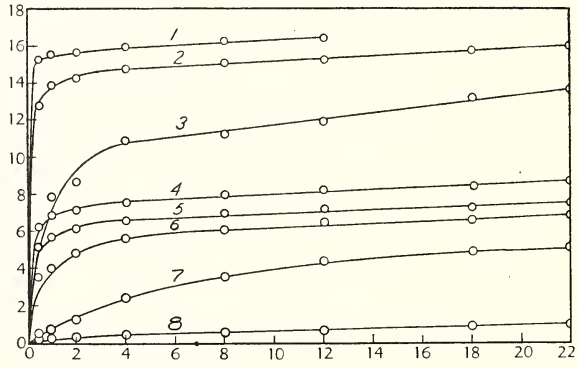

Fig. 5. Rates of Hydrolysis of Esters in the "Unactivated" and "Activated" Systems. Curve 1. Methyl acrylate "Activated"; Curve 2. Methyl methacrylate "Activated"; Curve 3. Butyl methacrylate "Activated"; Curve 4. Methyl acrylate "Unactivated"; 5. Ethyl acrylate "Unactivated"; Curve 6. Methyl methacrylate "Unactivated"; Curve 7. Ethyl methacrylate "Unactivated"; Curve 8. Butyl methacrylate "Unactivated".

of 1 N acetic acid must be added to the same system before a pH of 8.6 results. Therefore, it is reasoned that 6.5 milliequivalents (ml. x normality) of acid is liberated by ester hydrolysis in three hours. By following this same procedure for other reaction times the actual rate of hydrolysis curve is found for ethyl acrylate in the "unactivated" system. Figure 5 includes the rates of hydrolysis curves for the various esters in the "unactivated" and "activated" systems.

Conclusions

The conclusions that can be drawn from this rate of hydrolysis study are as follows:

1. The greatest amount of hydrolysis takes place within the first 2 to 4 hours for most esters in either "unactivated" or "activated" systems.

2. The rate of hydrolysis after 2 to 4 hours is quite uniform for all esters in both systems.

3. The excess alkali of the "activated" system is neutralized very quickly when methyl acrylate or methyl methacrylate is present, but with butyl methacrylate the reaction is much slower. Therefore, it is questionable whether the excess alkali is able to play its usual accelerating role in systems containing low molecular weight acrylate and methacrylate esters.

4. Acrylate esters are more easily hydrolyzed than methacrylate esters of the same molecular weight (e.g. ethyl acrylate and methyl methacrylate). This may be attributed to steric hindrance in the alpha-substituted acid.

Acknowledgment

The authors wish to express their gratitude to the General Tire and Rubber Company for its financial support of this work through the Purdue Research Foundation.

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The Relative Stability of Ferric Iron Complexes

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Ferric iron is a strong complex former and usually exists as a complex ion in solution. Each ferric complex has a characteristic hue which is shown by a spectral transmittancy curve. The change in this curve on the addition of other anions was used to establish the stability of the complex.

The transmittancy measurements were made with the Coleman Universal Spectrophotometer, Model 11. They were determined in the 350 to 750 mu. range, using 1.31 cm. absorption cells. Redistilled water was used in the reference cell. The measurements were made in 10 mu. intervals using a deep purple filter in the 350-400 range, a purple filter in the 400-650 range, and a red filter in the 650-750 range. There is a break in the curve when the filter is changed at 400 mu. which is seen in the figures.

It was assumed that the ferric ion has a coordination number of six so all the solutions were prepared on this basis. A standard solution of approximately 0.1 *M* ferric chloride was prepared by dissolving ferric chloride hexahydrate in redistilled water that was 0.3 *M* in hydrochloric acid. The exact molarity of the ferric ion was determined by titration with a standard potassium dichromate solution using sodium diphenylaminesulfonate as an internal indicator. Eighty-seven hundredths ml. of this standard solution, diluted to 100 ml. gave a solution 0.001 *M* in ferric ion. The stock solutions of the anions were prepared so that 1 ml. of the solution, diluted to 100 ml. was 0.006 *N* in the desired anion. The potassium or sodium salt of the anion was used.

The effect of each anion was measured in the presence of the chloride ion and the transmittancy curve compared to the curve for ferric chloride. These curves were used as a standard for that particular ferric complex.

There was no difference in the type of curve formed when the reagents were added in a different order.

Each anion was measured in the presence of every other anion and from the total results the stability list was established. The curve for the ferric cyanide complex was not changed by the presence of any other anion so the ferric cyanide complex was assumed to be the most stable. The nitrate ion had no effect on any of the curves for the other complexes so it was assumed to be the least stable. Since the phosphate ion formed a turbid solution with the acetate, tetraborate, sulfate, and tartrate complexes its position was obtained only by indirect evidence.

In figures 1,2,3, and 4 it is shown how the stability was established. These figures show only one or two of the curves for a certain anion but each position determined has been confirmed from the curves with the other anions.

In each figure the ordinate is the percent transmittancy and the abscissa is the wave length in mu.

The stability was established by comparing the curve for the mixture of two ions with the original curve for each complex. The curve of the complex that the mixture more closely resembled was the curve of the more stable complex.

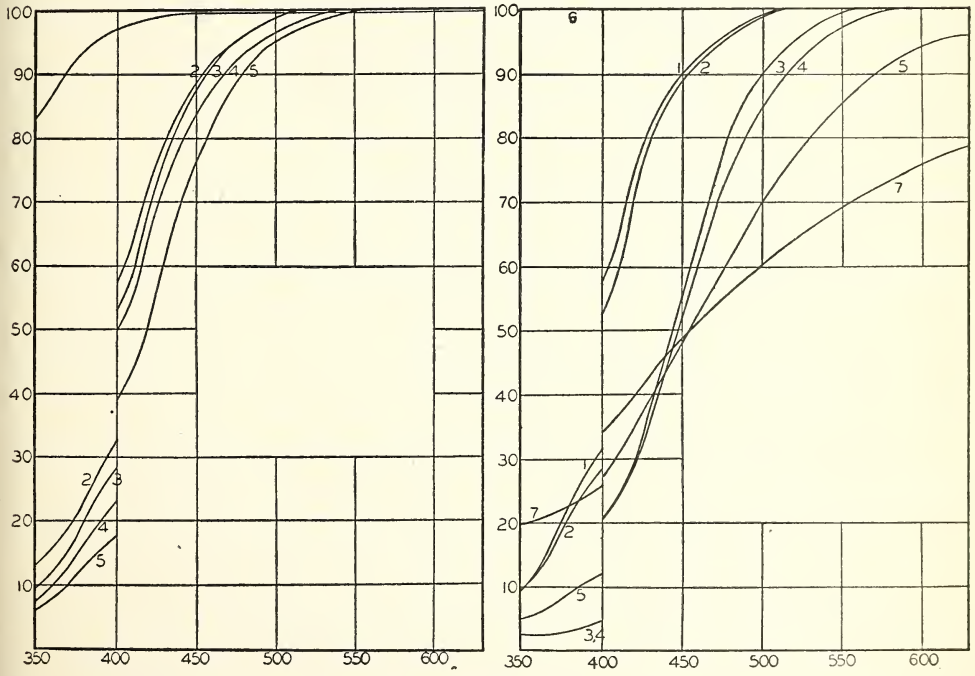


Fig. 1. Transmittancy curves for the Ferric complexes of: 1) Phosphate ion; 2) Phosphate and Oxalate ions; 3) Oxalate ion; 4) Citrate ion; 5) Citrate and Oxalate ions.

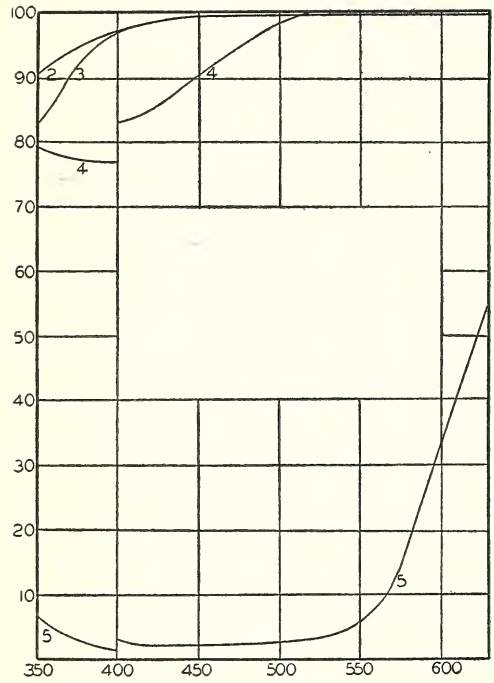
Fig. 2. Transmittancy curves for the Ferric complexes of: 1) Oxalate and Tartrate ions; 2) Oxalate ion; 3) Tartrate ion; 4) Tartrate and Acetate ions; 5) Acetate ion; 6) Fluoride ion; 7) Fluoride and Acetate ions.

In figure one it is seen that the citrate complex is more stable than the oxalate complex which is more stable than the phosphate complex.

In figure two it is seen that the oxalate complex is more stable than the tartrate complex which is more stable than the acetate complex. The fluoride complex is less stable than the acetate complex.

In figure three it is seen that the phosphate complex is more stable than the fluoride complex which is more stable than the thiocyanate complex.

In figure four it is seen that the thiocyanate complex is more stable than both the tetraborate and the sulfate complexes. The tetraborate



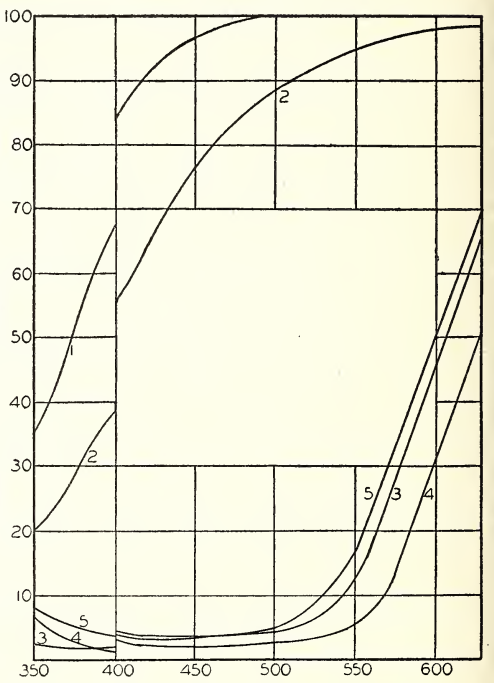


Fig. 3. Transmittancy curves for the Ferric complexes of: 1) Fluoride ion; 2) Fluoride and Phosphate ions; 3) Phosphate ion; 4) Fluoride and Thiocyanate ions; 5) Thiocyanate ion.

Fig. 4. Tranmittancy curves for the Ferric complexes of: 1) Sulfate ion; 2) Tetraborate ion; 3) Tetraborate and Thiocyanate ions; 4) Thiocyanate ion; 5) Sulfate and Thiocyanate ions.

complex with the sulfate ion formed a turbid solution so the tetraborate complex was placed above the sulfate complex on the evidence that it changed the curves for the acetate, citrate, fluoride, and oxalate complexes while the sulfate ion had no effect on these curves.

The bromide ion had a small effect only on the curve for the sulfate complex.

The relative stability observed for the complexes, the most stable being listed first, is as follows:

Cyanide
Citrate
Oxalate
Tartrate
Acetate
Phosphate
Fluoride
Thiocyanate
Tetraborate
Sulfate
Chloride
Bromide
Nitrate

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The Preparation and Properties of Certain Acyl Derivatives of Sulfamide

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A method for preparing sulfamide that can be adapted to commercial production has been described (1). Since there is a similarity in the structure and in the chemical properties between urea and sulfamide, and since some acyl derivatives of urea possess valuable pharmacological properties, this availability of sulfamide made it desirable to prepare acyl derivatives of sulfamide and to test their physiological action. This paper concerns only the preparation of these derivatives.

It was found that the N-acyl and the N,N'-diacyl sulfamides were formed by the action of acylating agents in the proper mole quantities. The diacylsulfamides were formed by the action of the acylating agent on sulfamide without a solvent. It was necessary, however, to use a solvent (ethyl acetate) to prepare the monosubstituted sulfamides.

Seven new compounds were prepared and characterized:

1. N-Acetylsulfamide, m.p. 157° decomp.
2. N-Propionylsulfamide, m.p. 148° decomp.
3. N-Butyrylsulfamide, m.p. 145° decomp.
4. N,N'-Diacetylsulfamide, m.p. 165° decomp.
5. N,N'-Dipropionylsulfamide, m.p. 171° decomp.
6. N,N'-Dibutyrylsulfamide, m.p. 159° decomp.
7. N,N'-Diisovalerylsulfamide, m.p. 157° decomp.

All of these compounds decomposed at their melting points, which were dependent upon the rate of heating. N,N'-Diacetylsulfamide, although melting sharply, melted at various temperatures from 144-170°. A technique similar to that used by Cortese and Bauman (2) was used to characterize the compounds. The melting point was taken as the temperature at which the compound melts completely in 30 $\pm$ 1 seconds.

Experimental

The preparations which follow are typical ones for each of the two types of compounds which were prepared—the monosubstituted and the disubstituted sulfamides. In the synthesis of the disubstituted compounds, dipropionyl- and dibutyrylsulfamide, the only difference in the procedure from that given is in the amounts of anhydride added. The diisolvalerylsulfamide was formed from isolvaleryl bromide and sulfamide. In all cases the amount of acylating agent was about 1.1 times the theoretical quantity. The monopropionyl- and monobutyrylsulfamide

were refluxed for four and three hours respectively instead of twenty minutes as given for the acetyl compound.

Preparation of N-Acetylsulfamide:

Six grams of sulfamide (m.p. 92-93°) is disolved in boiling ethyl acetate (150-175 ml.) in a 500 ml. round bottom flask fitted with a reflux condenser. A dropping funnel is inserted in a loosely fitted one-hole stopper and attached to the top of the condenser. Six ml. (6.4 gms.) of acetic anhydride to which had been added a few drops of conc. sulfuric acid is mixed with fifteen ml. of ethyl acetate and transferred to the dropping funnel. This mixture is allowed to drop slowly into the refluxing ethyl acetate solution.

When all the acetic anhydride-ethyl acetate mixture has been added, a calcium chloride drying tube is attached to the top of the reflux condenser instead of the dropping funnel. The mixture is refluxed for twenty minutes, then 100 ml. of ethyl acetate distilled off. The remaining solution is transferred to a 125 ml. florence flask and allowed to cool. Small white crystals are deposited on the sides of the flask. Weight of crude product, 4.5 gms. (52%). Small needles precipitate upon crystallization from absolute ethyl alcohol. After three crystallizations from abosolute alcohol, the product melts with decomposition at 157°. It is soluble in water, alcohol, and acetone. Analysis: N calculated, 20.29; N found, 20.05, 20.10.

Preparation of N,N'-Diacetylsulfamide:

Twelve ml. (12.9 gms.) of acetic anhydride, to which had been added a few drops of conc. sulfuric acid, is added slowly and with stirring to six grams of sulfamide (m.p. 92-93°) in a 125 ml. erlenmeyer flask. A very vigorous reaction takes place with the evolution of heat. The reaction mixture is warmed on a steam bath for one hour with intermittent stirring. On cooling, the mass solidifies and is crystallized from 60% ethyl alcohol. White needles are formed. Yield 5 gms. (55%). The product melts with decomposition after three crystallizations from 60% ethyl alcohol at 165°. Analysis: N calculated, 15.55; N found, 15.37, 15.15.

Summary

1. Mono- or disubstituted sulfamides may be prepared from the action of an acylating agent or sulfamide. In the latter case, no solvent is necessary.

2. Seven N-substituted sulfamides were prepared and characterized.

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A Spectrophotometric Study of Certain Methods for the Colorimetric Determination of Tin

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Introduction. Tin is usually determined by the separation of metastannic acid and subsequent ignition to the oxide which is weighed or by a titrimetric procedure. Neither of these methods is very satisfactory for the determination if the sample contains less than one percent of tin.

Several organic reagents are used for the qualitative detection of tin. Diazine green (S) (1), and cacotheline (2) seemed promising for use in a quantitative method.

Diazine green (S) forms a blue-green solution. Upon the addition of tin (II) in low acidic solution the color changes to deep red; in a highly acidic solution the color fades to a pale yellow. The latter reaction is more sensitive to slight changes in the concentration of tin.

Cacotheline forms an orange hued solution which changes to a red-purple upon the addition of a tin (II) solution.

Apparatus and Reagents. All measurements were made with a Beckman Quartz spectrophotometer using 2.00 ± 0.03 cm. cells. The band width varied from 1 to 5 mu.

A standard tin solution was prepared using 2.000 g. of reagent grade granulated tin dissolved in 100 ml. of concentrated hydrochloric acid and diluted to 2000 ml. with redistilled water.

A solution of cacotheline was prepared by dissolving 0.100 g. of solid reagent (E.K. 4396) in 250 ml. of redistilled water.

A solution of diazin green (S) was prepared by dissolving 0.100 g. of solid reagent (Janus green (s) E.K. 4444) in 250 ml. of redistilled water.

Concentrated hydrochloric acid cp and 30 mesh zinc, cp were used.

Reduction Procedure. Transfer an aliquot of the sample, free from nitrate ion, containing an amount of tin within the range of the particular method to be used to a 50 ml. volumetric flask. The volume of sample should be 5 ml. or less so that the reduction will proceed rapidly. Add 1.5 g. of 30 mesh zinc and 1 ml. of concentrated hydrochloric acid if the sample is not acidic. Stopper the flask loosely and place the flask on the edge of the steam plate for 2-3 minutes. After becoming warm, place the flask on the steam plate for 2-3 minutes more. Remove the flask and rapidly add the amount of hydrochloric acid required by the particular method, replacing the stopper loosely. Just before the last

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pieces of zinc disappear, force the stopper in tightly. Cool the solution to room temperature under a cold water tap taking care not to start with too cold water since the flask might break.

Diazin green method. To the sample just reduced, containing 23 ml. of hydrochloric acid and 8-20 ppm. of tin, add 5 ml. of reagent by use of a pipet with a cut off tip. The stopper is used to help shut off the mouth of the flask as the pipet drains. Immediately replace the stopper and mix by swirling. Color development requires 5-10 minutes. For low concentrations of tin use the five minute development time. Dilute the solution to volume with freshly boiled distilled water. Mix thoroughly and read the per cent transmittancy at once at 655 mu. Use distilled water in the reference cell. The oxygen from the air reoxidizes the reagent fairly rapidly hence the necessity for making the reading as soon as possible after dilution to volume.

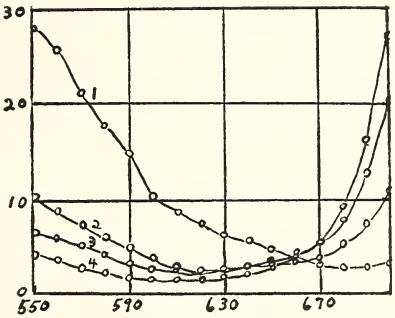

FIG. 1. Diazin Green method. Vertical scale is per cent transmittancy. Horizontal scale represents mu. Curve 1 represents 2 ml. reagent, 44 ml. HCl; curve 2 represents 2 ml. reagent, 25 ml. HCl; curve 3 represents 2 ml. reagent, 20 ml. HCl; curve 4 represents 2 ml. reagent, 15 ml. HCl.

When different concentrations of acid are used the per cent transmittancy curves show an isobestic point at about 655 mu. (Fig. 1). This happens to be the wavelength at which maximum sensitivity to concentration changes was observed hence it is convenient to measure at that wavelength as slight variations in the concentration of acid will have little effect upon the determination.

The reagent seems to be reasonably stable. However, transmittancies obtained for a given amount of tin and a given reagent solution are not usually the same on different days. Therefore, to use this reagent for quantitative determinations one must redetermine the calibration curve each day using standard samples.

This system does not follow Beer's law exactly. (Fig. 2, A). It can be used in the concentration range of 8-20 ppm. of tin.

Figure 3 shows a typical set of curves obtained using the concentration range specified.

Using 1:1 sulfuric acid and 2:1 phosphoric acid the same color change of blue-green to pale yellow was observed upon the addition of

tin (II) solutions. It was impossible to obtain complete reduction of the tin when these acids were used.

Cacotheline method. To the sample just reduced, containing 8 ml. of hydrochloric acid and 4-16 ppm. of tin, add 10 ml. of reagent by the use of a pipet with a cut off tip. The stopper is used to help shut off the top of the flask as the pipet drains. Immediately replace the stopper and mix by swirling. Then dilute to volume with freshly boiled distilled water. Mix thoroughly and read the per cent transmittancy at once at 560 mu. (Fig. 4). Use distilled water in the reference cell. The oxygen from the air reoxidizes the reagent fairly rapidly, hence the

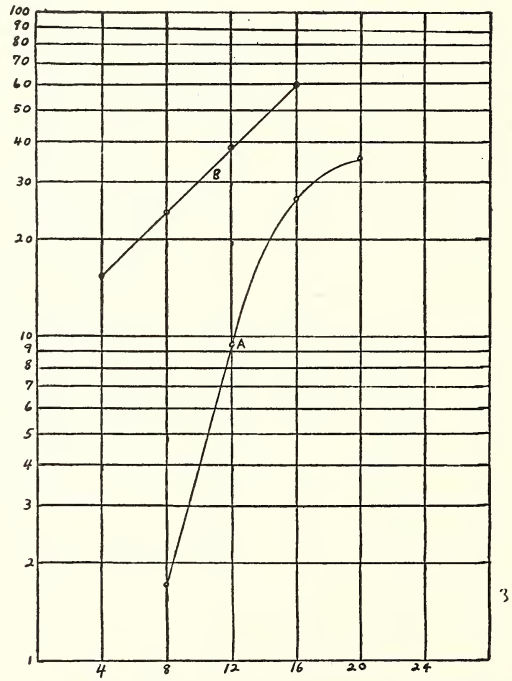

FIG. 2. Beer's Law curve. A, Diazin Green method. B, Cacotheline method. Vertical scale is per cent transmittancy, horizontal scale represents ppm. tin.

necessity for making the reading as soon as possible after dilution to volume.

This reagent seems to be unstable. An old solution will react to give a more dense color than one freshly prepared. Two freshly prepared reagent solutions will not give the same values. The calibration curve is a straight line so that it is necessary to check but one standard sample each day and draw a new line with a corresponding slope to the previously determined one. This system does follow Beer's law. (Fig. 2, B).

A combination of Corning filters No. 349 and No. 978 show a maximum transmittancy at about 560 mu. Consequently one could use the cacotheline method and with this filter combination make his measurements by use of a filter photometer.

Summary. Of these two methods the cacotheline method has given the best reproducibility. The concentration ranges are 8-20 ppm. of tin using diazin green (S) and 4-16 ppm. using cacotheline when using 2 cm. cells. The greatest difficulty with either method is the fact that reoxidation of the reduced reagent is rapid upon exposure to the air. A lesser difficulty is the necessity for redetermining the calibration curves

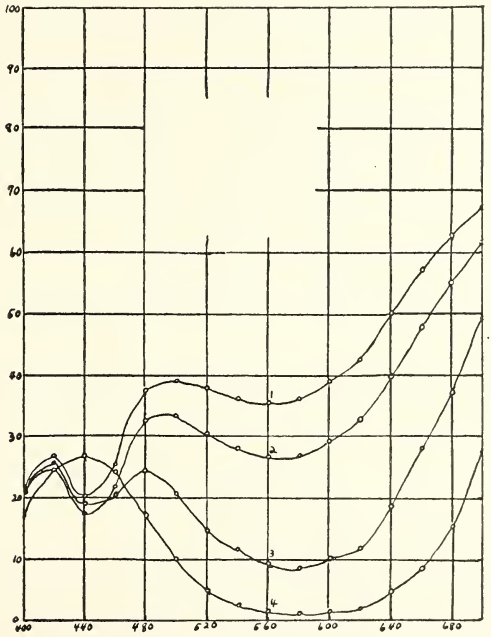

FIG. 3. Diazin Green method. Concentration curves. Vertical scale is per cent transmittancy. Horizontal scale represents mu. Curve 1 represents 20 ppm. tin; curve 2 represents 16 ppm. tin; curve 3 represents 12 ppm. tin; curve 4 represents 8 ppm. tin.

each day by analyzing standard tin samples. The usual precision of a colorimetric method, namely 1-3%, can be obtained by using the carefully controlled conditions described.

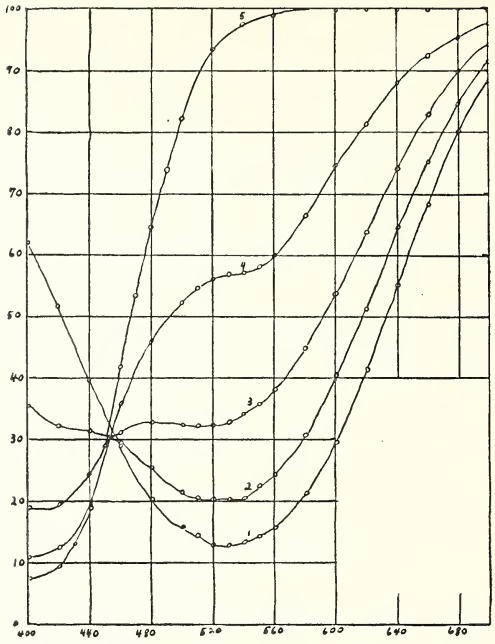

FIG. 4. Cacotheline method. Concentration curves. 10 ml. reagent and 10 ml. HCl. Vertical scale is per cent transparency. Horizontal scale represents mu. Curve 1 represents 16 ppm. tin; curve 2 represents 12 ppm. tin; curve 3 represents 8 ppm. tin; curve 4 represents 4 ppm. tin; curve 5 is the reagent curve.

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Addition Agents for Electrodeposition of Tin from Stannous Sulfate—Hydrofluoric Acid Solutions

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General Statement

Numerous studies have been made of addition agents for the electroposition of tin from sulfuric acid solutions, but only a few publications (1, 2, 3, 4, 8) of research with hydrofluoric acid or fluorides in the baths have appeared. The object of having fluorides in the bath is that hydrolysis with consequent precipitation of basic stannic salts is avoided.

It is necessary to add small quantities of organic material to tin plating baths in order to obtain smooth, solid cathode deposits rather than loose masses of crystals that are always formed if no suitable restraining or "addition agent" is present.

Electroplating of tin has become very important in coating iron for the making of "tin" cans. By the electro-method any thickness of tin can be applied, whereas, by the old process of dipping the iron in molten tin, only much thicker coatings can be obtained. Thus a great saving of tin is possible.

Experimental

Wax beakers of about 150 ml. capacity were used. Wax coated glass stirrers, run at about 90 r.p.m., provided the necessary agitation.

The cast tin anodes had an area of 16 sq. cm. The iron cathodes had an area of six sq. cm. and were prepared from used cans which were detinned in a solution of hot sodium hydroxide and sodium nitrate.

Since stannous fluoride was not available, a mixture of stannous sulfate, 100 g./l., and hydrofluoric acid, 35 g./l., was used. Each experimental bath had a volume of 100 ml., and one cathode and one anode were used in each.

The procedure for testing addition agents was as follows: One-tenth gram (1 g./l.) of the addition agent being tested was added to the bath. If the deposit was unsatisfactory, further multiples of this weight were added until one gram (10 g./l.) had been added. If the results were still negative an additional gram of the addition agent was added whereby the total concentration of addition agent would be 20 g./l. If the deposit deteriorated upon increasing the amount of addition agent, a new bath was prepared with less than one tenth gram of the addition agent (less than 1 g./l.). New cathodes were used with each change in concentration of the compound being tested. Obviously, the quantity of any addition agent that could be used was limited by the solubility for those that

were not very soluble. In some cases parallel baths containing 100 g./l. of sulfuric acid instead of the hydrofluoric acid were tested to obtain a comparison of the two types of baths. All baths were operated at room temperature. The cathode current density was held at 3 amp./sq.dm. or about 28 amp./sq. ft.

Since glue is widely used as an addition agent in many plating baths and since glue (5, 6) with cresol or naphthol gives excellent results in the sulfate tin bath, a series of baths was tested containing 1 g./l. of animal glue (freshly prepared). Glue, by itself, was of little value. However, glue together with *o*-cresol, β-naphthol, or NWO[1] gave smooth deposits without badly projecting crystalline growths but of a visibly crystalline nature. Glue plus resorcinol, tannic acid (an insoluble precipitate formed), eugenol, *m*-cresol, sorghum molasses, β-hydroxyethyl-*p*-toluidine, cymenetergitol-4 suspension, phloroglucinol, sulfanilic acid, tartaric acid, salicylic acid, thiourea, gum tragacanth, quinoline, glycine, tergitol-4, or β-hydroxyethyl-*m*-toluidine gave coarsely crystalline deposits.

Parallel experiments with all sulfate baths, always gave better deposits than did the baths containing hydrofluoric acid. However, anode corrosion was good and less sludge and precipitated material formed in the hydrofluoric acid baths.

Gum tragacanth, by itself, was ineffective and in combination with all the various other things listed above with glue, it gave loose, crystalline deposits. The combination with eugenol was a little less crystalline than the others.

Potato starch[2] with eugenol, quinoline, tartaric acid, salicylaldehyde, thymolsulfonthalein, *m*-cresol, β-naphthol, glycine, guaiacol, sulfanilic acid, sorgham molasses, catechol, tergitol-4, resorcinol, *p*-hydroxyacetophenone, or β-hydroxyethyl-*p*-toluidine gave very crystalline deposits. The potato starch with β-hydroxyethyl-*m*-toluidine, thymolsulfonthalein, or eugenol gave deposits that were less crystalline, but analogous baths without the starch gave equivalent deposits.

Dextrin with the other materials was ineffective except that there was some improvement with eugenol.

Gum arabic, tested with a few other materials, gave loose, crystalline deposits in all cases.

Caramel, a patented (7) addition agent, was ineffective either alone or in combination with eugenol, gum tragacanth, quinoline, β-hydroxyethyl-*m*-toluidine, or peptone.

Sorghum molasses, by itself, in a concentration of 10 g./l. (dry weight) definitely restrained the formation of loose crystals; greater concentrations did not increase the effect. Sorghum with glue, *m*-cresol, gum tragacanth, quinoline, dextrin, tannic acid, vinylphenol, 8-hydroxyquino-

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[1] NWO is a mixture of aromatic phenolic compounds recovered in refining of mineral oils.

[2] The addition agent was prepared by boiling starch in distilled water and adding aliquots of this solution.

line, sulfanilamide, phoridizin, guinea green B (NaOH solution), *p*-tert-amyl-*o*-cresol, tergitol-4, thymolsulfonthalein, β-naphthol, catechol, or quinoline was ineffective; β-hydroxyethyl-*m*-toluidine, eugenol, NWO, or guaiacol proved somewhat effective; with quinoline, β-hydroxyethyl-*m*-toluidine, or tergitol, the deposits were without projecting trees but were visibly crystalline.

Sunset yellow[3], a water soluble dye, in quantities less than 10 g./l. seemed entirely ineffective. With concentrations greater than this, compact but coarsely crystalline deposits were obtained. Ponceau 3R[4] and carmine were ineffective.

Thymolsulfonthalein (1 g./l.) gave firm but crystalline deposits. Greater concentrations did not improve the deposits. Eugenol and eugenol with starch, or β-naphthol with thymolsulfonthalein gave similar deposits. Thymolsulfonphthalein with *m*-cresol, glue, β-hydroxyethyl-*m*-toluidine, or sorghum gave loosely crystalline deposits.

Guinea green[5], 0.1 g./l., gave heavy firm crystals. This dye with *p*-tert-amyl-*o*-cresol, sorghum, gum arabic, quinoline, 8-hydroxyquinoline, tergitol-4, *α,α'*-dimethylbenzylphenol, or β-hydroxyethyl-*m*-toluidine gave less satisfactory deposits than with the dye alone. Guinea green, together with quinoline, tergitol-4, and sorghum gave very dense white deposits. A similar bath substituting 8-hydroxyquinoline for quinoline gave somewhat coarser but brighter deposits. Guinea green B together with both β-hydroxyethyl-*m*-toluidine and *n*-octyl alcohol gave visibly crystalline deposits without projecting crystals.

Quinoline was ineffective, but with eugenol, tergitol-4, or guaiacol, the crystalline growth was restrained. With vinylphenol or glycine only loose crystals were obtained. 8-Hydroxyquinoline was ineffective as were its combinations with tergitol-4 or guaiacol. With β-hydroxyethyl-*m*-toluidine, the excessively crystalline growth at the edges was decreased.

Sulfanilic acid, cyclohexylamine, glycine, *o*-aminophenol, hydroquinone, 2-amino-2-methyl-1-propinol, pyridine, *o*-toluidine, *p*-toluidine, and *o*-anisidine were all ineffective.

β-Hydroxyethyl-*m*-toluidine, but not β-hydroxyethyl-*p*-toluidine, prevented the growth of projecting crystals and with starch, *m*-cresol, or cymenesulfonic acid, there was no further improvement. With glue, peptone, or carbowax 1500, loose crystals resulted.

M-cresol, *o*-cresol, eugenol, β-naphthol, or catechol, was of no value as an addition agent. Eugenol with cymene sulfonic acid and quinoline gave compact but visibly crystalline deposits. Guaiacol prevented excessively loose crystal formation and treeing. However, the surface of the deposit was coarsely crystalline.

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[3] A search through the dye catalogs available failed to establish its identity. It is a legal food color dye.

[4] Sodium salt of β-cumene-azo-β-naphthol-3,6-disulfonic acid.

[5] Sodium salt of diphenyl diethyl diamino triphenyl carbinol sulfonic acid anhydride.

Tergitol-4[6] alone or with *n*-octyl alcohol, cymene sulfonic acid, *m*-cresol, glue, or eugenol was of no value.

The following were ineffective: Naphthalene-1,5-disulfonic acid alone or in combination with *o*-anisidine, carmine or *o*-toluidine; toluene sulfonic acid alone or with *m*-cresol, eugenol, or *o*-cresol; Turkey red oil or sulfonated tall oil alone or with *m*-cresol; egg albumin, cellusolve, saponin, carbowax 1500, carbowax 4500, Victor wetting agent 54B, 4-*tert*-butyl-*m*-cresol, peptone, dioxane, potassium ethyl xanthate, triethylcarbinol, tannic acid, *n*-octyl alcohol, trisodium phosphate, phloroglucinol, or phloridizin.

Conclusions

A wide variety of materials was tested for their effect as addition agents for the stannous sulfate-hydrofluoric acid electrolytic bath. Of the phenols, *m*-cresol, *o*-cresol, β-naphthol, NWO, and guaiacol were found effective if used together with another addition agent of the type glue, sorghum, or tergitol-4. Eugenol was found effective with a variety of compounds.

Guinea green B used with various materials in the concentration 0.1 g./l. was effective as an addition agent. β-Hydroxyethyl-*m*-toluidine was a good addition agent.

Tergitol-4 was shown to be a fair addition agent in a few combinations but its effect was variable.

The use of hydrofluoric acid was a distinct advantage in that the baths remained clear and free from any precipitate. However, hydrofluoric acid was distinctly objectional in that it always caused the deposits to be more crystalline and less firm than with the same addition agents in a sulfuric acid bath.

Corrosion of the anodes was generally good. Intercrystalline corrosion was at a minimum. Usually a very loose, finely divided, black, but easily removed, film formed upon the anodes during operation.

There was no gasing at the electrodes.

Tests were made on a sufficient number of baths to indicate a cathode efficiency approaching one hundred per cent. No tests were made on anode efficiency.

Although very many substances were tried as addition agents for the first time, no new ones were found that could be recommended for use in electroplating.

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[6] 2-methyl-7-ethyl-4-undecanol sulfate.

ENTOMOLOGY

Chairman: G. E. Lehker, Purdue University

Arlo Vance, U. S. Department of Agriculture, Purdue University was elected chairman for 1947.

ABSTRACTS

Studies on the attractiveness of dent corn to moths of the European corn borer. Ray T. Everly, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture.—Differences in the number of eggs laid by moths of the European corn borer (*Pyrausta nubilalis*, (Hbn.)) on different kinds of dent corn have been observed and reported by several writers. Recent detailed studies have been made to evaluate the differences and to determine their possible usefulness in control of the European corn borer. Available data indicate that the attractiveness of corn to the corn borer moth is a chemotropic response due to the presence of certain odorous substances in the plant tissues. However, chromophotic responses, particularly to invisible radiations, and responses to the physical characteristics of the ovipositing surfaces of the plants may also contribute to the variations in the numbers of eggs deposited on different kinds of corn. Two factors independent of inherent differences in the attractiveness of corn to the corn borer moth must be measured and taken into account in evaluating the kinds of corn in the test. These two factors are height of the corn during the early summer period of oviposition and plant maturity as measured by the date of midsilking during the late summer period of oviposition. In tests conducted over the three-year period 1943-45 at Lafayette, Indiana, inbred line Illinois A was outstanding in its unattractiveness. Inbred lines Wisconsin CC5 and Illinois R4 were relatively unattractive. Inbred lines Iowa L317, Indiana WF9, and Indiana Tr were very attractive. Similar results were obtained when these unattractive and attractive inbred lines were tested in single-cross combinations, indicating that the factors responsible for such ovipositional differences are inherited. It has been observed that when most of the corn in a large area is planted late and is therefore small and relatively unattractive, corn borer moths deposit more of their eggs on other host plants. In some areas where corn is not planted, or where the corn borer moths emerge before corn is available to them, the eggs are laid on other host plants. Therefore, if unattractiveness could be bred into hybrid corn, it is reasonable to expect a lower egg population on such corn, as a greater proportion of the eggs would be laid on other plants.

The control of certain insects by eliminating their animal vectors. MILTON CAROLINE, U. S. Fish and Wildlife Service.—Certain Hexapoda and Acarina such as fleas, mites and ticks can be more easily controlled by eliminating their animal vectors. This is a discussion of the pests involved, their animal vectors, and the best means of eliminating such hosts. Special attention is given to the control of rodents and birds.

Date of planting of dent corn in relation to infestations and populations of the multi-brood European corn borer.—H. O. DEAY, Purdue University.—A five-year study of the relation of the date of planting of dent corn to infestations and populations of the multi-brooded corn borer shows that the percentage of stalks infested and the average population per stalk are less in corn planted during the 10-day period from May 25th to June 5th than they are in corn planted either earlier or later. The earlier that corn is planted the more it is attacked by first-brood corn borers, and the later it is planted the more it is attacked by the second brood. The first brood does not damage corn planted after June 1st, and the second does very little damage to corn planted before this date. The yield of corn was found to be higher in plantings made from May 20th to June 5th than in earlier and later ones.

Insects of Indiana for 1946

J. J. Davis, Purdue University Agricultural Experiment Station

Some very unusual weather conditions occurred in 1946 which reflect the insect problems of the year. Table I shows clearly these weather conditions.

Table I. Comparative Monthly Weather Data for Indiana, 1946

Month		Temperature		Precipitation		Number of Days		
		State Mean °F	Departure from Normal °F	State Average Inches	Departure from Normal Inches	Clear	Partly Cloudy	Cloudy
1945 November	Normal	42.4		3.05				
	1945	44.0	+1.6	3.38	+0.33	8	7	15
December	Normal	32.1		2.72				
	1945	25.6	—6.5	2.33	—0.39	8	6	17
1946 January	Normal	29.0		2.95				
	1946	30.8	+1.8	1.57	—1.38	10	6	15
February	Normal	30.7		2.45				
	1946	34.6	+3.9	3.09	+0.64	10	6	12
March	Normal	41.0		3.77				
	1946	52.8	+11.8	3.11	—0.66	12	9	10
April	Normal	51.9		3.58				
	1946	54.2	+2.3	1.72	—1.86	12	10	8
May	Normal	62.3		4.09				
	1946	60.0	—2.3	6.06	+1.97	8	9	14
June	Normal	71.6		3.91				
	1946	71.3	—0.3	4.12	+0.21	14	10	6
July	Normal	75.7		3.31				
	1946	75.1	—0.6	2.62	—0.69	19	9	3
August	Normal	73.6		3.34				
	1946	69.6	—4.0	3.31	+0.03	13	13	5
September	Normal	67.2		3.29				
	1946	66.8	—0.4	1.35	—1.94	17	9	4
October	Normal	55.0		2.75				
	1946	59.2	+4.2	2.71	—0.04	16	8	7

Beginning in *November*, 1945, we find that temperature changes were frequent and fluctuations sometimes large. The first half of the month warm weather predominated while the weather was reversed the last half. *December* averaged quite cool due to two weeks of very cool weather about the middle of the month. *January* of 1946 had several periods of rather cold weather, but the average was somewhat above normal and precipitation was less than normal. Warm weather predominated in all parts of the state during *February* and precipitation was slightly above normal. *March* was the warmest March on record and precipitation was slightly below normal, especially in the southern half of the state. During *April* the temperature fluctuated but averaged above normal. Precipitation was less than half than normal and it was the driest April since 1934. *May* conditions delayed spring planting. Cool weather prevailed but the deficiency for the state was not large. There was heavy precipitation in the south but much less in the northern area. *June* shows normal temperature but with rather heavy rainfall in the extreme northern counties and less than needed in central and southern Indiana. Following a rather cool May, summer thus far was generally pleasant with slightly below normal temperatures in June and July. Reversing the order of the preceeding month, the northern part of Indiana was generally quite dry in *July* and the southern part moderately wet. *August* was a very cool month, the third coolest on record, but precipitation was normal for most areas of the state. During *September* the temperature was slighly below average and precipitation much below normal. The mean *October* temperature was sixth highest in sixty years while precipitation was about normal for the month although the first half of the month was very dry.

Field Crop Insects

Chinch Bug *(Blissus leucopterus* Say). In spite of the large population of chinch bugs in the fall of 1944 and their successful hibernation, the unusually unfavorable weather during the spring and early summer of 1945 reduced the chinch bug population to harmless numbers. Continued unfavorable conditions in the Spring of 1946 prevented the bugs from increasing to destructive numbers. Surveys to date indicate no likelihood of serious damage in 1947.

European Corn Borer (*Pyrausta nubilalis* Hbn.) has not been a serious problem for three or four years, due to the fact that weather has prevented most corn planting until after the recommended planting date. It should be noted, however, that each year there are enough overwintering borers to develop a serious infestation the following year if conditions are favorable for early corn planting and if farmers plant early.

Grasshoppers *(Melanoplus femur-rubrum* DeG. et spp.) were spottedly abundant, especially in areas of drought or semi-drought, due largely to the fact that dry conditions forced the grasshoppers to migrate from their breeding areas, lowland areas, to cultivated crops. They were

destructive to vegetable gardens, but more so in orchards, eating and girdling the tender twigs.

Hessian Fly *(Phytophaga destructor* Say) caused some damage to wheat the past Spring, with the stubble infestations moderate to heavy and general throughout the state.

White Grubs *(Phyllophaga spp.)* were abundant in many parts of the northwestern quarter of the state, attacking rye, wheat, soybeans, and golf greens.

The Annual White Grub *(Cyclocephala* sp.) was destructive to lawn grass in several localities in central Indiana.

Wireworms (Elateridae) were destructive to corn in northern Indiana during June.

Corn earworm *(Heliothis obsoleta* Fab.). This pest was unusually scarce during the past season.

The Potato Leafhopper *(Empoasca fabae* Harr.) was abundant on alfalfa throughout the northern two-thirds of Indiana, causing conspicuous yellowing of the foliage.

The Northern Corn Root Worm (*Diabrotica longicornis* Say) damaged corn in the bottom lands of southwestern Indiana. The beetles were responsible for injury to corn fertilization by cutting the green silks. There is evidence this insect is becoming increasingly important in the muck areas of northern Indiana where corn is grown on the same ground year after year.

Clover Bud Weevil *(Hypera nigrirostris* Fab.) was responsible for damage to clover, especially in southwestern Indiana, the last of April and early May.

Clover White Grub *(Colaspis brunnea* Fab.) were destructive to corn in many localities where corn followed spring-plowed legumes.

Corn Seed Maggot *(Hylemyia cilicruca* Rond.) was more abundant than for a number of years, especially in the northern half of the state, attacking planted seeds of corn, beans and melon. Cold, wet weather was probably largely responsible.

The Corn Seed Beetle *(Agonoderus pallipes* Fab.) was rather common attacking planted seeds, especially sweet corn, in the northern half of the state during June.

The Common Stalk Borer (*Papaipema nebris* Gn.) was quite common in most regions of the state attacking corn, potatoes, tomatoes, wheat and oats.

The Spittle Bug *(Philaenus lineatus* L.) was more common and destructive than in any of the past 26 years for which we have records. It became conspicuous in May and early June, and although not uncommon in all sections of the state it was most abundant in the northern third. It became conspicuously noticeable on all kinds of vegetation, including especially parsley and other vegetable crops, alfalfa, clover, flowers, including chrysanthemum and commercial cut flower gardens, strawberry and juniper trees. This insect is present every year and

common along streams and similar shaded places. Apparently the general outbreak this year was the result of cool, wet and cloudy weather.

Vegetable Insects

Mexican Bean Beetles *(Epilachna varivestis* Muls.) were scattered but became rather generally abundant and destructive beginning in June.

The Pickle Worm *(Diaphania nitidalis* Stoll) was destructive in all sections of the state but especially so to melons and cucumbers, or pickles, in the southern third of the state.

Potato Flea Beetle *(Epitrix cucumeris* Harr.) and the Potato Leafhopper *(Empoasca fabae* Harr.) were generally abundant on potato beginning in early June.

Onion Thrips *(Thrips tabaci* Lind.). Injury began to show up in late June and became increasingly abundant and destructive as the season progressed. Excellent control was obtained with DDT.

A Serpentive Leafminer *(Agromyza pusilla* Meig.) became very abundant on potatoes where DDT was used.

Fruit Insects

Strawberry Leaf Roller *(Ancylis comptana* Fröl.) was quite abundant in the northern half of the state.

The Apple Maggot (*Rhagoletis pomonella* Walsh). During the past few years there has been a definite migration southward and this year it was received from as far south as Danville in Hendrichs County, about the center of the state. Only a few years ago it occurred only in the northern tier of counties adjoining Michigan.

Bark beetles, commonly known as Shot Hole Borers *(Scolytus rugulosus* Ratz.) were unusually abundant in some localities on plum and peach.

Oriental Fruit Moth *(Laspeyresia molesta* Busck). In the dry areas of northern Indiana the worms left the twigs because of the hardening of the twigs and ate pits in the peaches which at the time were apparently too green to permit normal entrance in the fruits.

The Codling Moth *(Carpocapsa pomonella* L.) was normally abundant in northern Indiana but less abundant in southern Indiana. This may be attributed to the fact that in northern Indiana weather conditions were approximately normal. In southern Indiana about half of the overwintering larvae emerged normally but a cold spell following prevented egg-laying. After this late cold weather about a third of the overwintering larvae emerged as adults, and because of their late appearance there was practically no third brood which normally occurs. The rather general use of DDT in southern Indiana was another factor in reducing the importance of the codling moth in southern Indiana.

Shade Tree and Shrub Insects

Walking Sticks *(Diapheromera femorata* Say) defoliated a 10-acre oak grove near Knox, Indiana, the latter half of September. From there they migrated to nearby apples and roses, which were similarly defoliated. From reports received they did not attack Chinese or American Elms.

Bagworms *(Thyridopteryx ephemeraeformis* Harr.) was common throughout the southern half of the state. One report was received from Hammond in the extreme northwest corner of the state, the farthest north ever reported in Indiana.

Catalpa Worms *(Ceratomia catalpae* Boisd.) were scattered but groves of catalpa were defoliated in many parts of the state.

Cottony Maple Scale *(Pulvinaria vitis* L.) seems to be on the increase in northern Indiana.

European Elm Scale *(Gossyparia spuria* Mod.) is abundant throughout the state and its presence in nurseries is especially important because it prevents nursery inspection certification. Control has been difficult due to the fact that dormant oil sprays are effective only in high concentratives and early summer treatments have been ineffective because of the long period of hatching. During the past season, Paul Ulman and Howard O. Deay carried on a series of tests with DDT in a nursery near Indianapolis. Wettable DDT in strengths of ½, 1, 2, 3, 4 and 5 per cent were used, applications being made in July, about one month after the first young were hatched. Complete control was obtained with all strengths of DDT.

The Juniper Webworm *(Dichomeris marginellus* Fab.) is definitely on the increase and has been reported from many sections of the state, both north and south.

Pine tip moth *(Rhyacionia frustrana* Comst.) was sent in from several scattered localities.

Locust Leaf Miner *(Chalepus dorsalis* Thumb.) was unusually abundant and occurred in noticeable numbers as far north as Rushville, in central Indiana. Almost every year the hillsides of extreme southern Indiana are brown because of the browned locust leaves resulting from leaf miner infestation.

The Red Spider *(Tetranychus telarius* L.) was definitely more abundant on shrubs and trees, also on greenhouse crops, and in the case of apples it became a problem where DDT was used.

Aphids have been unusually abundant during the past late summer and fall. The three most conspicuous were willow aphids *(Clavigerus = Melanoxantherium smithae* Monl.), sycamore aphids *(Longistigma caryae* Harr.) and maple aphids *(Periphyllus lyropictus* Kess. and *Drepanaphis acerifoliae* Thos.). The willow aphids were especially obnoxious because of their fall migrating habits to nearby buildings and furnishings where they leave blood red stains when crushed. The maple aphids were especially annoying because of the abundant mist-like honeydew given off,

covering the leaves with a shiny sticky surface which interferes with transpiration, and by leaving glistening spots on the radiator and other parts of automobiles parked nearby.

Miscellaneous Insects

Stored Grain Insects were of normal occurrence.

Termites *(Reticulitermes flavipes* Koll.) were the subject of more inquiries than in any previous normal year for which we have records. The accompanying graph shows the interest in termites based on letter inquiries received from 1923 to 1946, during which period we have

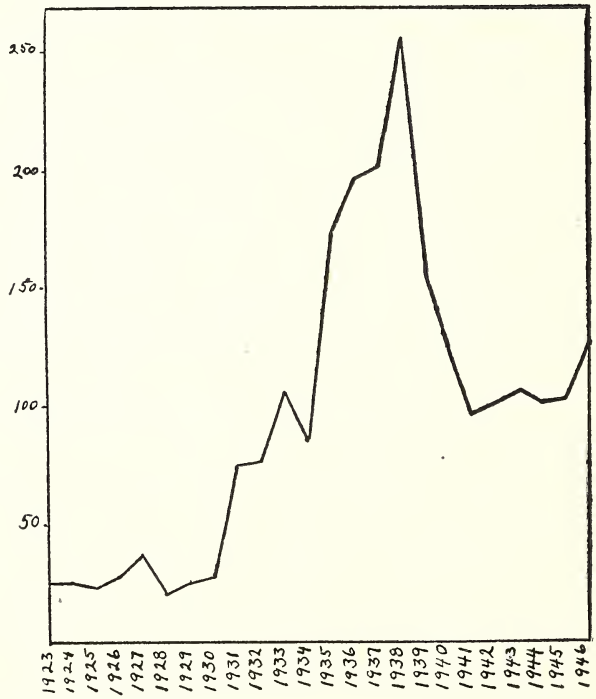

Fig. 1. Number of termite letter inquiries each year from 1923 to 1946.

maintained records of all insect inquiries. It will be noticed that but few inquiries were received from 1923 to 1930. Beginning in 1931 and until 1934 increasing inquiries were received which resulted in publicity and extension activities to aid home owners. This publicity apparently was responsible for a rapid increase in inquiries with the peak in 1938. From that date the inquiries decreased and for the past six years the inquiries have reached a normal level.

Powder Post Beetles *(Lyctus* spp.) have been increasingly important during the past few years in all sections of the state.

Ants of various species have been the subject of many inquiries. For the most part the inquiries referred to ants annoying in the lawn and garden although many referred to ants as household pests, and not a few referred to winged ants confused with termites.

Boxelder Bugs *(Leptocoris trivittatus* Say) were again abundant and annoying in homes where they sought winter quarters.

Cluster or Attic Flies *(Pollenia rudis* Fab.) were more abundant than usual this past fall.

Cockroaches of all kinds, but especially the German roach *(Blattella germanica* L.), were reported as household pests more than usual.

Fleas *(Ctenocephalus felis* Bouche and *Pulex irritans* L.) were again major pests the same as for the past few years. Excellent control has been obtained in buildings, lawns, and on animals by use of DDT.

Flies, especially the house fly (*Musca domestica* L.) were less abundant the past year than most years.

The Brown Dog Tick *(Rhipicephalus sanguineus* Latr.) has been the subject of many inquiries and there is little doubt but this dog and household pest is on the increase in Indiana.

Tree-Hole Mosquitoes, in Tippecanoe County, Indiana

IVAN C. BROOKS, Purdue University

During the first week in August it was brought to my attention by Dr. R. M. Cable that some mosquitoes were breeding in a tree hole located in West Lafayette.

The breeding place was in a cavity at the base of a very large American elm *(Ulmus americana* L.). The cavity contained approximately five to six gallons of water. The water contained an abundance of debris, including dead leaves, dead grass, much paper, and numerous cigarette butts. The water was a dark amber color and appeared to have a high concentration of tannin.

Four species of mosquitoes were found to be breeding in this habitat: *Orthopodomyia alba* Baker, *O. signifera* (Coq.), *Aedes triseriatus* (Say), and *Anopheles barberi* Coq.

Some of the larvae were brought into the laboratory, placed in round, enamel pudding pans covered with square pieces of plate glass, where they remained until they reached the adult stage. Some of the adults were killed with chloroform and mounted on card points for identification and study. A representative number of larvae were preserved in alcohol for further study.

Anopheles barberi Coq.

This is not a new record for the state. This species was taken in 1942 in Vigo and Allen county and again in 1943 in Vigo county in a light trap (Christensen & Harmston, 1944). This is a new record for Tippecanoe county, however. Since this species breeds only in tree holes, it is not taken very often.

In comparison to other anophelines this species is very small and delicate, measuring approximately 3.5 mm. in length. The wings are not pictured, as is the case with most species of anophelines occurring in Indiana, but are covered entirely with blackish brown scales.

The larvae are readily identified. It is the only species of Anopheles that has plumose, lateral hairs on the first six abdominal segments.

According to Matheson (1946) this species overwinters in the North as second-stage larvae frozen solidly in the ice in tree holes. The author first discovered larvae breeding in a tree hole during the first week in August. On the nineteenth of August the last of the larvae disappeared and to date (November) have not reappeared. This would tend to indicate that *A. barberi* overwinters in the egg stage in this section of the United States, particularly, since no adults have been observed in the vicinity of the breeding place. Much more study and observation will be necessary to determine the exact biology of *A. barberi.*

Aedes triseriatus (Say)

This is the only species of the four that has ever been taken in a light trap by the author. The females are very annoying biters. This species breeds continuously throughout the season. The winter is passed in the egg stage (Matheson, 1946). The eggs are laid upon the sides of the tree hole, just above the water line, singly or in small groups, attached firmly to the surface. When covered with water, the eggs hatch. There are probably several broods during the season but this has not been determined definitely. The appearance of adults throughout the summer may be due to the development of successive broods of larvae from overwintered eggs hatching at different times (Howard, Dyar, & Knab, 1917).

The water level in the tree hole became very low during the middle of September, at which time no larvae or adults were present. Shortly after that time a heavy rain filled the hole and during the first part of October the larvae started appearing again. This might indicate that the late fall larvae hatched from overwintered eggs which never received optimum conditions earlier in the season.

This is the only species of Aedes that breeds in tree holes in North America.

Orthopodomyia signifera (Coq.) and *O. alba* Baker

The members of this genus are very strikingly marked and easily distinguished from the other genera of mosquitoes. They are represented in the United States by only two species, *signifera* and *alba* which can not be distinguished accurately in the adult stage. The only published records of *alba* are from Ithaca, New York and Adams Dam, Alabama (Matheson, 1946). Since *alba* is indistinguishable from *signifera* in the adult stage, it is quite probable that *alba* enjoys a much wider distribution than the above records would indicate. The larvae of these two species are quite distinctive and can be readily identified.

The air tube of *signifera* larvae is about three times as long as wide while in *alba* it is only about twice as long as wide. The pecten is absent in both species. The hair tuft is large and multiple in the case of *signifera* and located just before the half. *Alba* has a small hair tuft located at the proximal fourth of the air tube. The anal segment of *signifera* is longer than wide and ringed by the dorsal plate. The anal segment of *alba* is about as wide as long and is not ringed by the dorsal plate. The sixth, seventh, and eighth abdominal segments of *signifera* have dorsal sclerotized plates. These are lacking in *alba*. The anal gills are much shorter in *alba* than in *signifera*.

Matheson (1946) states that the larvae of *O. alba* can survive freezing and that this species passes the winter in the larval stage. *O. signifera* larvae are all killed by freezing and it is not known how the latter species overwinters.

The eggs of both species are laid singly, close to the waterline on the side of the hole containing the water (Howard, Dyar, & Knab, 1917). The egg stage is very short, and larval development in the first two in-

stars is very rapid. However, development during the remainder of the larval stage is rather slow.

Both species have been breeding continuously since the first week in August under natural conditions as well as in the laboratory.

The adult mosquitoes are capable of mating and reproducing without receiving any food other than that which is obtained from the water in the breeding pans. A great deal more study and observation will be necessary to determine the exact life cycles of these two species of mosquitos.

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Some Notes on the Biology and Control of Tomato Hornworms*

George E. Gould, Purdue University

The common species of hornworm found on tomatoes in Indiana is normally *Protoparce sexta* Johan., although the other species, *P. quinquemaculata* Haw., occasionally becomes more abundant. Both species feed upon the foliage of the tomato plant and, when abundant, may eat into the green fruits. The two hornworms may be found together on the plants, although the relative abundance and life cycles of the two differ as does their reaction to certain insecticides. Serious losses from the feeding of these worms occur infrequently, although defoliation of plants in September is common.

In order to study the seasonal abundance and the damage of the hornworms, counts of the populations of five widely scattered fields around Lafayette were made at regular intervals in 1943, 1944 and 1945. In addition, counts were made in Botany and Entomology plots in these years and in 1946. The results of these counts given in Table 1 show that in two seasons the worms appeared early in July, while in the other two they appeared the last of July. The percentage of the true tomato hornworm *(sexta)* in the total population varied greatly but in three years out of the five increased as the season advanced. On the other hand, the total worm population in these fields reached its peak around August 1 in 1945 and 1946 and in late September in 1943 and 1944. In the latter two years when the worm population was high in September the worms also appeared early in the season.

Damage to the Indiana tomato crop by hornworms has seldom been serious over the entire state, but each year some sections have reported severe damage. The southern half of the state, especially the Vincennes area, has had some losses every year which at times have resulted in complete defoliation by late August. In the Lafayette area most fields were defoliated in late September in 1943 and many fields in 1944, while isolated outbreaks occurred about August 1 in 1945 and 1946. Extensive defoliation and the eating of green fruits of these early outbreaks caused more damage, according to growers, than the more populous late outbreaks in September. The destruction of the foliage late in the season exposed the fruit and hastened its maturity.

In making counts of worm injury in fields it was found difficult and time-consuming to locate all larvae. Consequently in the inspection either the worms or recent feeding was counted. The infestation in the fields varied considerably and was influenced by the date of planting, the

* In November, 1946, the common names of the two species of hornworms on tomatoes were reversed, so that the officially accepted common name for **P. quinquemaculata** is now the tomato hornworm.

TABLE I.—The percentage of tomato hornworm, *Protoparce sexta* Johan., and the percentage of parasitism in the total hornworm population found in tomato fields around Lafayette, 1943-1946.

Date		Percentage of all hornworms		Percentage of sexta
		during the season	parasitized	
July 6	1943	x	x	x
	1944	4	0	10
	1945	No worms	—	—
	1946	No worms	—	—
July 17	1943	5	—	—
	1944	7	0	12
	1945	No worms	—	—
	1946	No worms	—	—
July 27	1943	6	—	—
	1944	1	0	x
	1945	35	3	42
	1946	35	0	10
Aug. 7	1943	5	62	43
	1944	No worms	—	—
	1945	38	5	11
	1946	52	0	25
Aug. 17	1943	2	75	64
	1944	3	10	40
	1945	No worms	—	—
	1946	6	0	84
Aug. 27	1943	3	37	96
	1944	13	10	28
	1945	24	80	47
	1946	3	20	80
Sept. 10	1943	27	56	98
	1944	30	22	8
	1945	2	30	100
	1946	4	30	100
Sept. 20	1943	52	46	94
	1944	42	18	12
	1945	1	20	100
	1946	1	22	100

size of plants and the abundance of weeds. Weeds covering tomato plants and the early planting and harvesting of the crop greatly reduced the total number of worms, while in years such as 1943 and 1944 healthy, vigorous plants in September were stripped of foliage. In one field with light injury the count was 167 per 100 plants on September 23, 1943, while the following year no injury resulted on the same farm from counts of 123 on September 11 and 171 on September 22. On another farm where the yield was reduced 50 per cent by worms stripping the foliage and eating into the fruit, the counts on September 11 and 22 were 98 and 181 respectively. From observations in the various fields during the four-year period it was determined that a count of 60 per 100 plants around August 1 indicated possible damage from hornworms, while a count of 100 in late September indicated a dangerous population.

Both species of hornworm were found to overwinter in the soil as pupa at a depth of four to eight inches, with a few at a greater depth. The first emergence of moths in the spring varied with seasonal conditions, but usually occurred from June 15 to July 10. In 1946 an investigation of the unusual infestation revealed that 40 or 50 plants in a five acre field near Ash Grove were stripped on June 25. Since the larvae had already matured, it was assumed that eggs were on the Georgia-raised plants when set on May 30. The first moths caught at lights at Lafayette in 1946 were in early July.

Records from both bait traps using amyl salcylate and light traps were used in determining the seasonal abundance of the two species. A bait trap at the edge of a 14-acre tomato field captured 278 female and 166 male moths in 1943, while in 1944 the two species were separated with a count of 7 females and 10 males of *P. sexta* and 99 females and 51 males of *quinquemaculata*. In 1945 the trap was located on a farm several miles from where tomatoes were growing or had been grown in the previous year and captured 4 females and 4 males of *sexta* and 30 females and 6 males of *quinquemaculata*. Records from the moths caught at bait and light traps as well as field counts of larvae indicated one and at least a partial second generation of both species. For instance in 1943 the moth catch from July 20 to August 8 was low and the larval counts from August 12 to 24 were low, while in 1944 the moth catch from July 11 to August 2 was low and larvae were almost completely absent from July 26 to August 15. In addition, no larvae were found in 1945 on the August 17 inspection, while in 1946 larvae were scarce around August 20.

Moths of both species flew at dusk and were attracted to such flowering plants as petunia, Jimson weed and tobacco. Eggs laid by the females on the tomato foliage or stems hatched in three or four days in July and August and four to six days in September. It was difficult to separate the small larvae of the two species by the characteristic white markings of the large worms, but even in the first instar the red horn on the abdomen of *sexta* and the blue or black horn of *quinquemaculata* were quite distinct. The larval development of *sexta* required a period of about eighteen days in August with two days in

the first instar, three days each in the second and third instars, four days in the fourth instar and six days in the fifth instar. In September these periods were somewhat longer. The life cycle of *quinquemaculata* was similar to *sexta* and required about twenty-one days in early September.

At maturity the larva left the plant and entered the soil for pupation. Frequently larvae crawled several hundred feet before entering the soil.

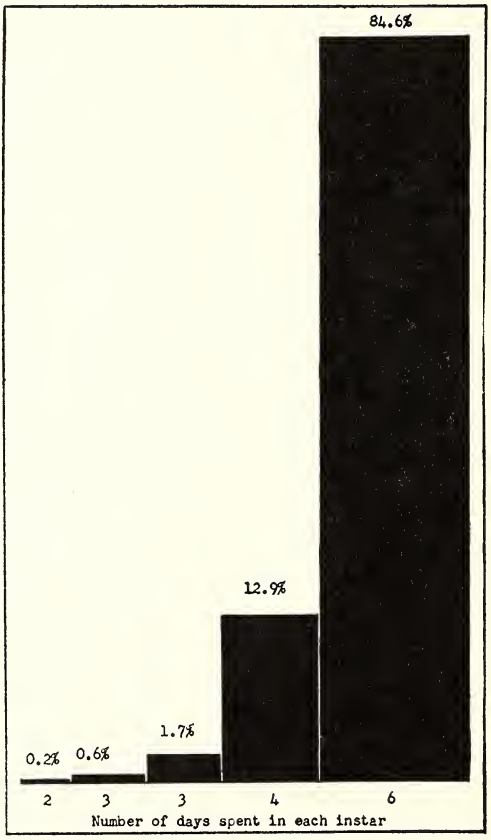

Fig. 1. The number of days in each larval instar and the relative proportion of the total larval food consumed in each larval instar of *Protoparce sexta*.

In cages the mature larvae did no feeding, but frequently crawled around the edge for hours and sometimes for days before pupation. Of eight mature larvae of *quinquemaculata* placed on a caged tomato plant from July 6 to 13 six moths emerged August 2 to 9, or approximately 26 days as pupae. The pupal period for larvae maturing around August 1 was about 30 days, although only a small per cent emerged. Larvae maturing in September did not emerge as moths the same season.

In the laboratory several larvae were reared, and their daily weight and the amount of tomato foliage consumed were determined. At hatching the larvae weighed about 2 mg. each and consumed about 2 sq. cm. of foliage in the first instar. In the fifth (last) instar larvae of *sexta* consumed 1420 sq. cm. of foliage in six days and reached a peak weight of 7650 mg. The larvae of *quinquemaculata* required a similar quantity of food although their weight was somewhat higher. The enormous quantity of foliage consumed in the fifth instar as compared with the other four instars is shown in figure 1 and indicates the importance of controlling the worms early in their development.

The hymenopterous parasite, *Apanteles congregatus* (Say), has been present each year, but the percentage of parasitism has varied greatly. Usually the parasitized worms were more abundant late in the summer, with the highest record of 80 per cent on August 27 in 1945. It was also noted that early in the season the parasite pupal cages were found on worms two-thirds grown or larger, while in September many of the worms dying from parasites were only a fourth grown.

In the past the standard insecticides for the control of hornworms have been calcium and lead arsenate. These two poisons were not effective at concentrations recommended for other insects, while at higher concentrations the possibility of poisonous residues on the ripening fruit had to be considered. Several of the new insecticides have been investigated to determine their efficiency in comparison with the standard materials in the control of hornworms.

Few tomato growers of the state have attempted hornworm control measures as suitable equipment has not been available, and, in addition, the expense of a sprayer or duster for tomatoes alone has seldom been justified by the infrequent worm outbreaks. Growers in the Vincennes area and tomato sections of southern Indiana have had some serious outbreaks and consequently have purchased some equipment. Row dusters and sprayers have been used on small tomato plants, but after the vines fill in the rows either spray booms must be carried over the plants or airplane dusting must be used. In the past six to eight years several thousand acres of tomatoes have been dusted one to three times each season for disease and insect control with a mixture containing an insoluble copper compound and about six per cent calcium arsenate. There has been no opportunity to check the efficiency of airplane dusting, but in tests on caged plants a 25 per cent calcium arsenate dust mixture was not satisfactory.

The hornworms used in cage tests were collected in the examination of fields and varied both in size and the proportion of the two species. In testing insecticides two methods were used: the plants were dusted or sprayed with the mixture and the larvae then placed on the plants, or the larvae were first placed on the plants and were hit by the insecticide application as it covered the plant. Screen wire cages were removed from the plants usually on the fourth day and counts were made of the live and dead insects.

In 1944 a 25 per cent calcium arsenate dust gave about a 66 per cent kill of *P. sexta* and *quinquemaculata*, while a 40 per cent cryolite

mixture was slightly better. A water spray containing .05 per cent DDT (dichloro diphenyl trichloroethane) killed small larvae of both species on the plant at the time of application and all small larvae of *quinquemaculata* placed on the plant one and three days following the application, while no small larvae of *sexta* placed on the plant the day after the application were killed. In five cage tests where the plants were dusted with a 3 per cent DDT 98 per cent of the *quinquemaculata* larvae of assorted sizes were killed and only 11 per cent of the *sexta* larvae.

In 1945 the .05 per cent DDT spray gave a 66 per cent kill of *quinquemaculata* and a 20 per cent kill of *sexta*. A three percent DDT dust gave 84 per cent kill of the former and a 25 per cent kill of the latter, while a 7½ per cent DDT dust gave an 88 and a 44 per cent kill respectively.

In 1946 two new synthetic insecticides in addition to DDT were given some preliminary tests. These materials were hexachlorocyclohexane or benzene hexachloride and a new chemical now called chlordane. The first of these materials has at present a persistent, musty odor which would probably be retained by ripening tomatoes. Improvements are being made in the material from the standpoint of eliminating the odor and increasing the gamma isomer, the toxic ingredient. A dust mixture of hexachlorocyclohexane containing .3 gamma iosomer gave a 72 per cent kill of *P. quinquemaculata* and a 43 per cent kill of *sexta*. Chlordane prepared as a 5 per cent dust gave 73 and 30 per cent kills respectively, while a 2 per cent dust gave 91 and 43 per cent kills. Chlordane in an oil emulsion form gave an excellent but slow kill of the hornworms, with 84 per cent kill for *sexta* and 80 per cent for the other species. The 3 per cent DDT dust gave results similar to the two previous years with a kill of 20 per cent for *sexta* and 83 per cent for the other.

Summary. The two hornworms on tomatoes in Indiana have one and a partial second generation each year. The life cycle in July and August required about 50 days with 18 to 20 days of this time in the larval stage. In the fifth or last instar the hornworms consumed 87 per cent of the foliage eaten during the larval stage. The population of the two species varied from month to month in any season and from season to season. In three years out of five *sexta* became the predominant species in August and September. The identification of the species present in a field was important as it was found that *sexta* was more difficult to kill with some of the new synthetic insecticides. In cage tests DDT, hexachlorocyclohexane and chlordane gave fair results on the larvae of *quinquemaculata* but poor results with *sexta*. Although the hornworms were not destructively abundant in the state every year, isolated outbreaks did occur which often reduced the yields from 25 to 50 per cent.

The Distribution and Relative Seasonal Abundance of Indiana Species of Five Families of Dragonflies (Odonata, Calopterygidae, Petaluridae, Cordulegasteridae, Gomphidae and Aeshnidae)

B. Elwood Montgomery, Purdue University

Three previous papers (Montgomery, 1942, 1944, 1945) have indicated the relative seasonal abundance of the adults of the Indiana species of Agrionidae, Cordulidae and Libellulidae. These studies have been based upon the frequency of collection and observation of the several species during the 41-year period of 1900 to 1940 inclusive. The present paper continues these studies to all other families of Odonata found in Indiana, except the Lestidae.

Tabulations have been made from the records preserved in the notebooks of the late E. B. Williamson and of the author. The two charts presented here (Fig. 1 and 2) consist of time-frequency graphs for all Indiana species of the five families indicated. The graphs were constructed by tabulating the records for the entire 41 years by thirds of months and plotting the resulting frequencies at the midpoints (5th, 15th and 25th respectively) of these thirds.

During the period from 1900 to 1940, 51 species of the five families were collected or observed in Indiana. Six of these have been recorded in the state but once. No species was recorded for all of the 41 years; *Anax junius* (Drury) was reported for 35 years, *Calopteryx maculata* (Beauvois) for 34, and *Hetaerina americana* (Fabricius) and *Gomphus graslinellus* Walsh for 30 years each. The number of species of these five families recorded each year has varied from two, in 1923, to 27, in 1932. A few of these species are rather abundant, but many, including all the species belonging to the Petaluridae and Cordulegasteridae and many of the Gomphidae, are quite rare. The number of years in which each species was found is indicated immediately following the species name in the list below.

List of Species with Notes on Distribution and an Indication of the Number of Years Each Species Was Collected from 1900 to 1940 Inclusive

Calopterygidae

Calopteryx aequabile Say—15; transcontinental in southern Canada and the northern half of the United States, but the eastern (typical) subspecies appears to be confined to the region from Maine to Iowa. *C. angustipenne* (Selys)—1; Pennsylvania and Indiana to Georgia.

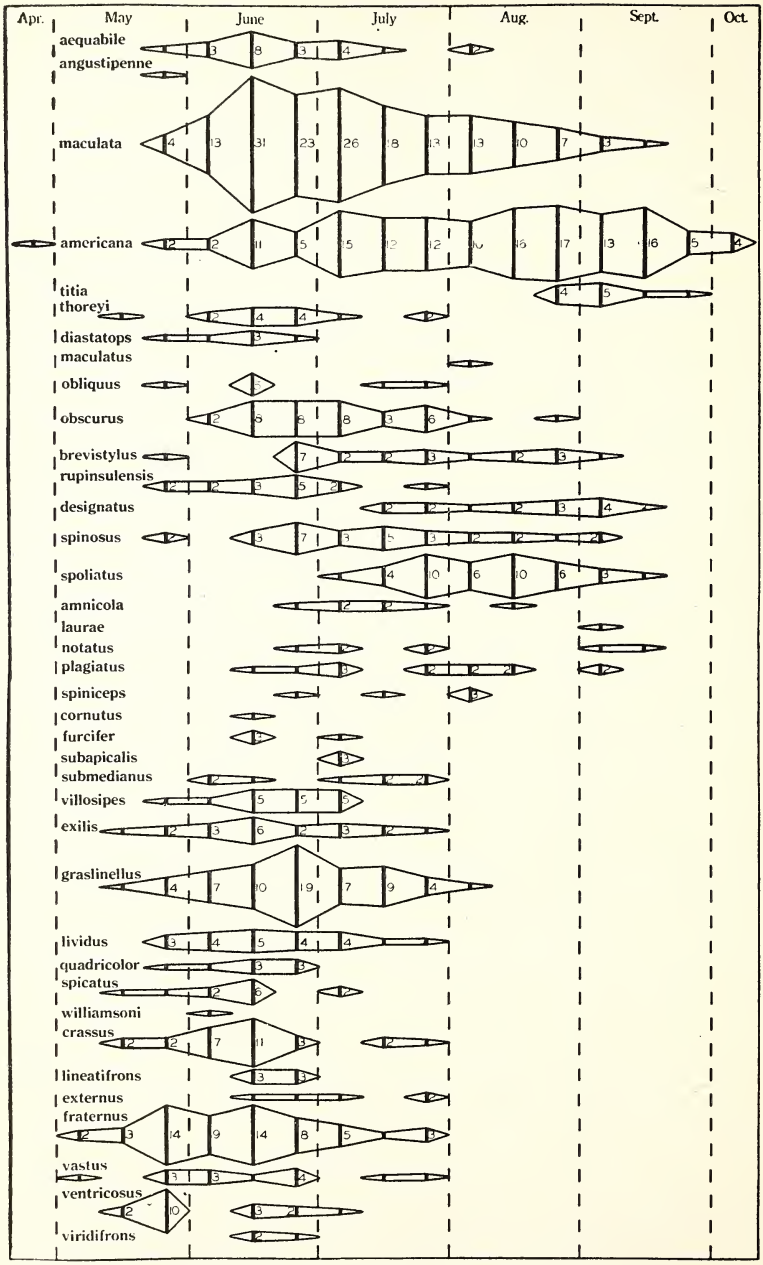

Fig. 1. The range of the flight season (or period of adult life) and the relative seasonal abundance of species of Calopterygidae (Calopteryx and Hetaerina), Petaluridae (Tachopteryx), Cordulegasteridae (Cordulegaster), and Gomphidae (Progomphus, Hagenius, Ophiogomphus, Erpetogomphus, Dromogomphus, Stylurus and Gomphus) in Indiana. Numbers near each bar indicate the number of collections of each species in each third of a month during the period of 1900 to 1940 inclusive; where no number is given the number of collections is one.

C. maculata (Beauvois)—34; Maritime Provinces and Manitoba to Florida and New Mexico.

Hetaerina americana (Fabricius)—30; Quebec and California to Guatemala. *H. titia* (Drury)—8; New Jersey and Michigan south and southwest to the West Indies and Central America.

Petaluridae

Tachopteryx thoreyi (Hagen)—9; New Hampshire and Michigan to Florida and Missouri.

Cordulegasteridae

Cordulegaster diastatops (Selys)—3; Maritime Provinces and Ontario to South Carolina. *C. maculatus* Selys—1; Maritime Provinces and Michigan to Florida. *C. obliquus* (Say)—6; Maine, Quebec and Wisconsin to New Jersey and Kansas.

Gomphidae

Progomphus obscurus (Rambur)—21; Massachusetts and Iowa to Florida and eastern Texas.

Hagenius brevistylus Selys—11; Maritime Provinces and Minnesota to Florida and Oklahoma.

Ophiogomphus rupinsulensis (Walsh)—10; New Brunswick and Saskatchewan to Tennessee and Missouri.

Erpetogomphus designatus Hagen—9; Ohio and Nevada to Florida and Mexico.

Dromogomphus spinosus Selys—14; Maine, Quebec and Wisconsin to Florida and Oklahoma. *D. spoliatus* (Hagen)—25; Ohio and Wisconsin to Georgia and Texas.

Stylurus amnicola (Walsh)—3; Quebec and Minnesota to North Carolina and Kansas. *S. laurae* Williamson—Michigan to Virginia and Georgia. *S. notatus* (Rambur)—6; Quebec and Manitoba to North Carolina and Tennessee. *S. plagiatus* (Selys)—5; New York and Michigan to Florida and Texas. *S. spiniceps* (Walsh)—4; Massachusetts, Quebec, and Wisconsin to South Carolina and Missouri.

Arigomphus cornutus (Tough)—1; Quebec and Manitoba to Indiana and Iowa. *A. furcifer* (Hagen)—4; Quebec to New Jersey and Iowa. *A. subapicalis* (Williamson)—2; Indiana, Illinois, Oklahoma and Texas. (Gloyd, 1941, has shown that this species is identical with *lentulus* Needham). *A. submedianus* (Williamson)—5; Michigan to Oklahoma. *A. villosipes* (Selys)—13; Massachusetts and Minnesota to Maryland and Indiana.

Gomphus exilis Selys—15; Maritime provinces and Wisconsin to Georgia. *G. graslinellus* Walsh—Ontario and Manitoba to Maryland and Ok-

lahoma, British Columbia. *G. lividus* Selys—14; Quebec and Wisconsin to Florida. *G. quadricolor* Walsh—7; Massachusetts and Wisconsin to Tennessee. *G. spicatus* Hagen—6; Maine, Quebec and Minnesota to New Jersey and Indiana. *G. williamsoni* Muttkowski —1; Wells County, Indiana.

Gomphurus crassus (Hagen)—17; Ontario to Tennessee and Iowa (Wilson's record from Red Wing, Minnesota, "A single female . . . in company with *G. vastus*", needs confirmation before this species is considered a member of the Minnesota fauna). *G. lineatifrons* (Calvert)—2; Michigan to Kentucky. *G. externus* (Hagen)—3; Michigan and Manitoba to Kentucky, Texas and Utah. *G. fraternus* (Say)—Quebec and Manitoba to Pennsylvania and Iowa. *G. vastus* (Walsh)—8; Quebec and Minnesota to Maryland and Kansas. *G. ventricosus* (Walsh)—Massachusetts to Wisconsin and Illinois. *G. viridifrons* (Hine)—Pennsylvania to Indiana.

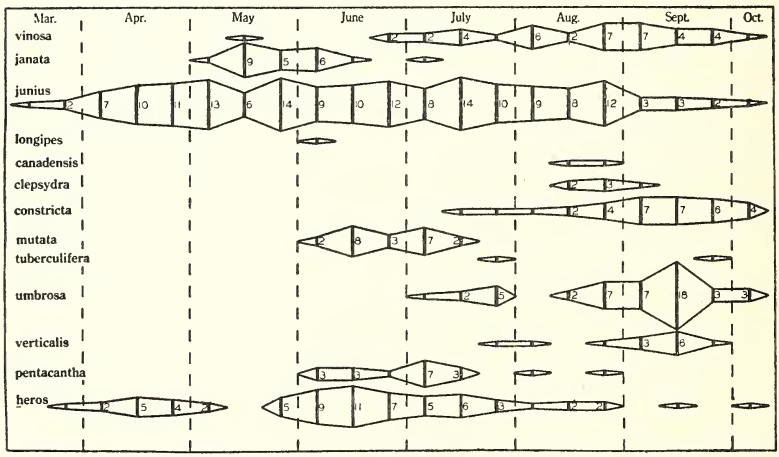

Fig. 2. The range of the flight season (or period of adult life) and the relative seasonal abundance of species of Aeshnidae (genera Boyeria, Basiaeschna, Anax, Aeshna, Nasiaeschna and Epaeschna) in Indiana. Numbers near each bar indicate the number of collections of each species in each third of a month during the period of 1900 to 1940 inclusively; where no number is given the number of collections is one.

Aeshnidae

Boyeria vinosa (Say)—21; Nova Scotia and Michigan to Florida and Arkansas.

Basiaeschna janata (Say)—12; Maritime Provinces and Wisconsin to Georgia and Oklahoma.

Anax junius (Drury)—35; North America from Alaska to Costa Rica and West Indies; Pacific Islands, and the west coast of Asia. *A.*

longipes Hagen—1; east coast from Massachusetts to Brazil; occasional inland records west to Indiana.

Aeshna canadensis Walker—1; transcontinental in Canada, southward in United States to Indiana and Missouri. *A. clepsydra* Say—4; Nova Scotia and Wisconsin to New Jersey and Indiana. *A. constricta* Say—17; Maritime Provinces to British Columbia, southward into New England, Kansas and Nevada. *A mutata* Hagen—10; Massachusetts to Michigan and Indiana. *A. tuberculifera* Walker—2; New England and Quebec to Wisconsin and Indiana; British Columbia. *A. umbrosa* Walker—25; transcontinental in Canada, southward to South Carolina, Oklahoma and Nevada. *A. verticalis* Hagen—11; Maritime Provinces and Wisconsin to Maryland and Illinois; California.

Nasiaeschna pentacantha (Rambur)—15; New England and Quebec to Florida and Texas.

Epiaeschna heros (Fabricius)—26; Maine, Quebec and Wisconsin to Florida and Mexico.

Both of the genera of Calopterygidae represented in Indiana are large, each containing more than 50 species. Calopteryx is Holarctic; six species are found in North America. The three species not recorded from Indiana are limited in their distribution to the Atlantic coastal states and *angustipenne* should be classed with these as eastern, as opposed to the more wide ranging *aequabile* and *maculata*. However, it should be noted that the transcontinental *aequabile* shows tendencies to subspeciation as four varieties have been described and the typical form does not appear to be found west of Iowa, nor in the far North (Walker, 1933, 1940, 1941.) Hetaerina is an American genus with the greatest number of species in Brazil. About ten species are found in Mexico, almost all of which range southward into Central America, or even in northern South America, but only four extend northward into the United States and two of these only into the border states.

Tachopteryx, the only genus of the family Petaluridae in eastern North America, is generally considered as monospecific. Kennedy (1917) erected a genus for two species, each of somewhat restricted range in the western states and Japan respectively, which were formerly included in this genus.

Cordulegaster, one of four genera of the family Cordulegasteridae, includes 23 species and subspecies according to the most recent revision (Fraser 1929). Nine of these species are North American; the others are distributed from the British Isles across southern Europe and Asia to China.

Of the genera of Gomphidae listed, two, Hagenius and Dromogomphus are restricted to the central and eastern states, two, Progomphus and Erpetogomphus are widely distributed in the new world and one, Ophiogomphus is Holarctic. Stylurus, Arigomphus and Gomphurus are generally not acceded full generic rank, but, if considered as distinct at all, are considered subgenera of Gomphus.

Progomphus includes about 25 described species ranging from Massachusetts and Oregon to Argentina with its metropolis in Brazil (Byers 1939). Three species occur in the United States; one of these appears to have a limited range in Florida, and the second is widely distributed throughout the region west of the range of *obscurus*. Ophiogomphus contains almost 30 species, of which approximately half are North American. Seven of these are limited to areas along or near the Atlantic Coast and seven occur in the far western states; *rupinsulensis* although it extends far into the central plains, is eastern and does not overlap the range of any western species. Dromogomphus includes only one species in addition to the two found in Indiana and the range of this third species is a very limited area in the southeastern region (Georgia).

Gomphus *(sens. lat.)* is a Holarctic genus of more than 125 nominal species. Of approximately 50 North American species only about five occur west of the Mississippi basin. The subgenera are rather distinct, although there has been some disagreement in the placement of certain species.

Of the six genera of Aeschnidae occurring in Indiana, three, Basiaeschna, Nasiaeschna and Epiaeschna are monotypical. Boyeria is a Holarctic genus of five species, two from North America and three from the Old World. Anax and Aeshna are large cosmopolitan genera with about 33 and 80 species, respectively. Five species of Anax and 26 of Aeshna occur in North America, north of Mexico.

In groups considered in earlier studies in this series—Agrionidae (Montgomery 1942, 1944), Cordulidae and Libellulidae (Montgomery 1945)—traces of correlation between the seasonal range of the species in Indiana and their geographical range or their evolutionary level were shown. No such relationships are evident in the groups treated in this paper, although there is some tendency for wide ranging species to have long seasonal ranges. *A junius* with the most extensive geographical range of any Indiana species, except *Pantala flavescens* (Fabricius), has the longest seasonal range in the state, although only slightly longer than that of *E. heros*. The species of Gomphus, including Arigomphus and Gomphurus, which are generally quite restricted in geographical range, have rather short, early seasons of adult flight. However, the species of Stylurus with approximately equal areas of geographical distribution have an entirely different pattern of adult flight period. In certain groups—Enallagma, Cordulidae and Libellulidae—northern species show a tendency to reach their maximum abundance, in Indiana, during the early season (Montgomery 1942, 1945), but the species of Aeshna which, except for *umbrosa*, reach their southern limit in Indiana, have late summer seasons of flight.

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The Use of Stilts in Peach Production

G. Edw. Marshall, Purdue University

In Indiana repeated attempts to colonize *Macrocentrus ancylivorus*, a parasite of the Oriental fruit moth, have failed in several sections of the State. No spray program yet devised, has been entirely successful in the control of this peach pest. In the areas where the insect is not parasitized in large numbers, the profitable growing of such peach varieties as Fleener and White Heath has become impossible. Mid-season Elberta is often 60 per cent infested.

For such areas, some effective method of control is needed, and one, "the twig-clipping method", has been investigated extensively. By this method, the infested twigs are removed early in the growing season at from five to seven day intervals. Similarly the infested fruits, which the larvae begin to enter as harvest approaches, are removed. The 1946 studies are interesting because this year clipping operations have been carried out using stilts while previously twig clipping operations have necessitated the use of ladders. Inasmuch as the six-year old trees, in the orchard under study, have been grown low to facilitate their use, stilts have proven to be most practical.

Through results of studies made from 1938 to 1942, it becomes evident that the Oriental fruit moth can be controlled by the twig-clipping method. During these first years of the investigation, when ladders had to be resorted to because the trees were high often it took from 15 to 20 minutes per tree to inspect and remove the infested twigs and fruits. Inasmuch as from 10 to 17 such operations are needed each season, the method would become more practical if the length of time necessary could be reduced.

In 1940 a small orchard of Gage Elberta peaches were planted in the Purdue Entomological Experimental Orchard near Mitchell to be grown low for clipping studies. These trees have had five crops on them and are approaching their prime. Every twig on the trees may be reached from the ground, from the crotch of the tree trunk, or by the use of stilts. The rather complete story, of the production of the 1946 crop on this isolated block of 25 Gage Elberta trees, and of the control operations as they were carried out, is as follows:

Approximately 28,930 peaches began development.

Of these, it is estimated that 5,620 were killed by frost on April 12th, when the temperature went down to 29 degrees F., at which time the diameter of the fruit was $\frac{5}{16}$ inches.

From the crop that remained, 11,575 were thinned off or went to the ground as pre-harvest drops. The dropping of the fruit was very heavy between June 20 and 29.

There remained 11,735 peaches which matured, and these averaged 110 per bushel. The average crop per tree approximated 4.3 bushels.

Infested twigs and fruits were removed 11 times during the season beginning June 20th. During the operations, 4,726 twigs were taken off and this averaged 189 per tree. Former studies indicate that an average of one live Oriental fruit moth larva is removed for every two twigs clipped off. The labor cost for this work was $21.56 or about 20 cents per bushel of peaches harvested.

The crop was disposed of as tree ripened fruit and the harvest began August 15th and lasted until September 4th. Brown rot and rodent injuries accounted for .6 per cent of the crop, 15.3 per cent were harvested as ripe drops and sold for $2.00 per bushel. The picked fruit amounted to 84.1 per cent of the total and sold for $4.00 per bushel.

Through this method of handling, no grading was necessary, brown rot peaches were removed at each of the six pickings and accordingly soon after infection set in. No curculio infestation remained in the orchard to hibernate and subsequently attack the 1947 crop.

For such a program, very little equipment is needed. San Jose scale and peach leaf curl must be controlled by spraying, and any type of sprayer which will break the spray stream into a fine mist and carry it 12 feet high, will do the job on low-grown trees. This is winter work and can be leisurely done. Occasionally brown rot will need to be controlled at harvest time and to do this, if the trees are not too tall and the orchard is not too large, a hand operated duster is just as satisfactory as a power machine. In the studies discussed here, operations for brown rot control were necessary only once in the past five years and that during the 1946 season. Two applications of sulphur dust were made. Although, during most seasons, curculio is held in check as the result of strict sanitation and the removal of faulty fruit at short intervals, if other measures against this insect are deemed necessary, a hand duster may be used for plantings of 200 trees or less. This same type of equipment may be used to control *Bacterium prunii*, if needed.

The average time necessary to clip the infested twigs for each tree, each operation, was 13.5 minutes. Fruit from the clipped block was compared with that from a neighboring commercial orchard of midseason Elberta. Harvest infestation figures were taken in the clipped block at two different periods in order that the stages of ripeness might be definitely stated.

Picking date	Commercially treated midseason Elberta	Clipped Gage Elberta	Stage of ripeness
August 15 infestation	40.67 percent		Hard ripe
August 25 infestation		10 to 12 percent	Hard ripe
September 3		20 percent	Tree ripe

In the commercial orchard, as shown in the table, the fruit was picked and marketed in the "hard ripe" stage and at that time it was 40.67 percent infested. At the same stage of ripeness though 10 days

later the Gage Elberta peaches from the clipped block was 10 to 12 percent infested. Inasmuch as this latter variety reaches a comparable stage of ripeness much later, from an infestation standpoint, this must be considered a disadvantage imposed on the Gage Elberta because the Oriental fruit moth has 12 days longer to develop a heavy infestation.

Infestation counts of "tree ripened" peaches were not available for the midseason Elbertas because harvest had been completed and the fruit sold bfore such a stage had developed. However, as shown in the table, the infestation of the clipped block on Sept. 3 was 20 per cent. This is 19 days after the counts were made on midseason Elberta. Nineteen days is more than half the time needed to develop a complete generation of the Oriental fruit moth and yet the infestation of the clipped block was only half as much as in the orchard which received the regular dust schedule suggested for commercial orchards.

This method of control of the Oriental fruit moth is discussed before the entomologists of Indiana for three reasons. In the first place, very little equipment is necessary for the small acreage grower, the one with 200 trees or less. Second, he can do most of the operations, both winter and summer, piecemeal and leisurely. As for the third reason, by this method, tree-ripened fruit of a quality considerably superior to that ordinarily available from large commercial orchards, can be produced, because the large acreage grower must harvest his crop sufficiently "hard ripe" to process in the usual way.

GEOLOGY AND GEOGRAPHY

Chairman: G. David Koch, Indiana State Teachers College

Dr. C. F. Deiss, Indiana University, was elected chairman of the section for 1947.

ABSTRACTS

Reforestation of Spoil Banks. Daniel Den Uyl, Purdue University. —For 20 years forest tree planting has been done on the spoil banks of stripped coal lands in Indiana. Approximately 12,000 acres of spoil banks have been planted and 30 species of forest trees have been used. Of the hardwood species planted, black locust (*Robinia pseudoacacie*) has been most commonly used while red pine (*Pinus resinosa*), white pine (*Pinus strobus*), and jack pine (*Pinus banksiana*) were the most commonly planted conifers. The success of tree planting appears to be dependent upon several factors such as soil type, age of spoil banks, tree species planted, quality of planting stock and method and care in planting.

The Whitewater canal. Norma Koch, Indianapolis Public Schools.— A moving picture presented views of three trips to the White Water valley. On the first trip pictures were taken of the aqueduct at Metamora before the acquisition by the state. On the second trip pictures were taken after the acquisition of the aqueduct by the state and the creation of the new state park. On the third trip pictures were taken of the surrounding country including Laurel and Connersville.

Some Effects of Glaciation Upon Agricultural Productivity in Morgan County

James R. Anderson, Indiana University

Introduction

Crossed by both the Wisconsin and the Illinoian Glacial Boundaries, Morgan County serves well as a political unit in which to study some of the significant influences of glaciation upon agriculture. No other Indiana county has such diverse soils as does Morgan, for six of the State's major soil regions are represented. The County also has considerable diversity in physiography and topography. Portions of two major physiographic regions, the Central Lowlands Province and the Interior Low Plateaus Province, are represented. Malott[1] places parts of Morgan County in three of Indiana's physiographic regions. The diverse soils, physiography, and topography have had a profound effect upon the production pattern. Average and high corn yields, apple production, and land assessment values have been studied to determine significant glacial influences.

Glacial Influences upon Topography and Soils

Approximately one-half of the County belongs to the Norman Upland, the other half to the Tipton Till Plain; two small areas are a part of the Mitchell Plain (in the west central and southwest). Several topographic contrasts closely related to glaciation are evident in the Norman Upland and Till Plain sections. From the air it is easy to distinguish the three major physiographic subdivisions. The northern and eastern parts are level to rolling. The central and southern sections are rough, dissected upland with considerable forest cover on the slopes, ridges, and hills, together with the creek and especially the White River Bottoms, which have much cropland. The Mitchell Plain is indicated by karst or sinkhole features which suggest to one who has flown over the war zones, an area that has been subject to aerial bombing. Several commercial apple orchards border some of the rougher areas, while one of the State's important forestry projects (Morgan-Monroe State Forest) occupies the south-central rough section. While these rough areas are low in productivity, they afford good examples of relatively profitable use of rough land.

The small steep-sided streams, the larger creeks, and White River have made an intricate drainage pattern. Partly because of the diagonal

[1] Logan, W. N., Cumings, E. R., Malott, C. A., Visher, S. S., et al—Handbook of Indiana Geology, Department of Conservation, No. 21 (1922) (pp. 66-256).

course of White River, the County has about 10% of its area in fertile first and second river bottoms. This valley is broader than the present river implies. Its breadth reflects the position of White River in relation to the melting Wisconsin ice sheets. Of the tremendous volume of melt water flowing away from this glacier, White River was so located in Morgan County that it received most of it. Looking at the Morgan County portion of the White River Valley and its relation to the Wisconsin Glacial Boundary (Fig. 1), the sudden widening of the valley below the boundary gives considerable support to the conclusion that melting ice was most significant in the formation of a broad fertile valley in much of the County. However, the fact that from 50 to 100 feet

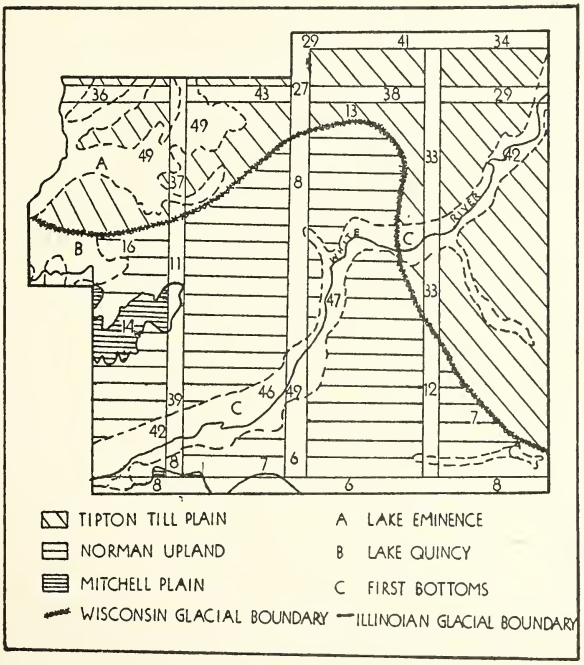

Fig. 1. Relationship between land assessment values and glaciation in Morgan County. Average dollar values per acre are based on samples of approximately 1000 acres for each location. Boundaries of the Mitchell Plain after H. P. Ulrich.

of the rock material through which White River has cut its course is easily eroded shale is of major significance.[2]

The till plain in Morgan County is more rolling than in counties immediately to the north as might be expected near the glacial margin. Likewise the thinner layer of till near the boundary means somewhat less fertile soils than those of the more deeply covered portions further

[2] Brown, R. T., 1883. Geology of Morgan County. Ann. Rept. Indiana Dept. Geol. and Nat. Hist. **13**:80.

north. Yet this glacial till has been of great importance, and underlies much of the County's best cropland. Particularly fertile is the Lake Eminence area, shown in figure 1. This former glacial lake has poor natural drainage; but artificial drainage soon opened up the area for farming. Another lacustrine flat, Lake Quincy, only a small part of which lies in Morgan County, has also benefited from the deposition of silts and clays. It is of Illinoian age, whereas Lake Eminence is within the outer Shelbyville Wisconsin Moraine. The Lake Quincy area does not have such fertile soils as does Lake Eminence because greater leaching has taken place there (12 to 15 feet). Lake Eminence deposits are leached only about five to six feet. This lake bed, with an area of some 30 square miles, is one of two fertile areas; the other is the White River Bottoms.[3]

Land assessment values reflect local contrasts in the potentiality for production of various crops. In figure 1 some of the relationships between physiography, topography, and land values are shown. The value per acre of farms sampled in making this map are from the land assessment values of 1932 (the last official land assessment); consequently these values are very low compared with value per acre for which land now usually sells. However, there is little reason to believe that the relative values have changed drastically, although the hilly areas (because of more rapid loss of fertility) have become somewhat relatively less valuable than the more level parts of the County. The north-south land assessment value profiles clearly indicate where the more fertile level land lies in comparison with the less fertile rough parts. In north-south profiles the abruptness is evident in every instance, indicating sudden rather than gradual transitions between hilly, less fertile areas and rolling to level, more fertile sections. For example, the average value of land for several farms situated just south of the Wisconsin Glacial Boundary in one section was $10 per acre, while for farms immediately to the north, it was $36 per acre. In the eastern part of the County the north-south contrast in land assessment values is not so great as in the central and western parts. This is due to the presence of some Indian Creek bottom land lying just south of the glacial boundary. In the eastern north-south profile, there is a steady northward increase in land values reflecting increased penetration of the glaciated region, and deeper till. The lack of abrupt changes for the White River Valley in this eastern profile indicates that the typical rolling Till Plain on both sides of the river grades into the bottom land. A greater difference exists in the north-south profiles than in those running east-west. This illustrates the fundamental role of glaciation upon the local physiography.

The diverse soils of Morgan County are especially significant in explaining the contrasts in crop yields. Most of the soils are of glacial origin. As all the soils were formed under similar forest conditions, they are normally light in color and low in nitrogen and organic materials; rainfall conditions have led to considerable leaching, particularly of lime; the soils are practically all low in nitrogen, phosphorus, and

[3] Thornbury, W. D., 1940. Glacial Lakes Quincy and Eminence. Proc. Ind. Acad. Sci., 49:131-144.

available potash. All of the soils except a few acres of muck are derived mainly from rock materials. Fine texture is a common characteristic, 85% being silt loam, 10% silty clay loams, and 5% relatively sandy.[4] The diversity is due to extent, depth, and characteristics of glacial deposits; time that leaching and stream dissection has been in progress; and difference in parent materials and drainage conditions during soil formation.

Four soils, comprising about 17% of the total acreage, are especially productive. The fertile Brookston and Cope series are situated in the northwestern part of the County adjacent to the productive and compact Toledo soils of Lake Eminence. This area of some 5,000 acres (Toledo) is equalled in fertility by most of the Genesee soils, although the latter have some less fertile phases. Some 20,000 acres of bottom land, principally along White River are very productive. In contrast to these fertile soils, which are among the most productive in the State, Morgan County has large areas of poor soils. The Muskingum and Cincinnati soils, which comprise 21% of the County's soils, are relatively infertile. Between these highly fertile and infertile soils are the remaining soils. The Russell, Fincastle, and Miami soils of the Till Plain comprise 28% of the soil area and are above average in productivity, but are not so fertile as the Toledo, Genesee, Brookston, and Cope soils.[5] The considerable acreage of relatively infertile Cincinnati and Muskingum soils aids in explaining the middle-of-the road position of the County in most phases of agriculture.

Glacial Influences and Corn Yields

Average yields: Morgan County ranks among Indiana's 92 Counties, 54th in total corn acreage and 46th in production (1934-43 average); the principal limitations are soils and topography. Corn occupies one-fifth of the total acreage of the County, but over one-half of the cropland. Only one other County (Pike) has a greater proportion of its cropland in corn. The wide White River bottoms and glacial Lake Eminence are largely responsible; there the natural fertility is sufficient to permit a short rotation with corn as the major crop. The relatively high rank (28th, see Fig. 2) of Morgan among Indiana counties in average corn yields is due to the natural productivity of these two areas. Of the 27 counties outranking Morgan in average yields, 22 have more of their area within the Till Plain than does Morgan—a telling point for the highly beneficial effects of glaciation in central Indiana.

Average corn yields correlate with soil and topography. The highest yields are in the Lake Eminence area with an average yield of 65 bushels per acre in 1945. Next in rank was the County's northern margin where the Till Plain commences to take on the characteristics typical of

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[4] Ulrich, H. P. and Assistants, 1937. Soil Survey of Morgan County, Purdue University, p. 95. To be published by the U. S. Dept. of Agriculture.

[5] Ulrich, *op. cit.* This summary discussion has been largely based on a soil map and acreage table prepared by Ulrich.

central Indiana. Here yields averaged 57 bushels per acre. The central portion of the Till Plain (not including the White River Valley) and the 2nd bottoms of White River have average yields of about 51 bushels, showing a progressive decline from north to south which correlates with the decrease in the depth of the Wisconsin drift. The overflow bottoms of White River have a "spotty" distribution of yields, which can be attributed to soil contrasts. The average was 53 bushels in 1945.

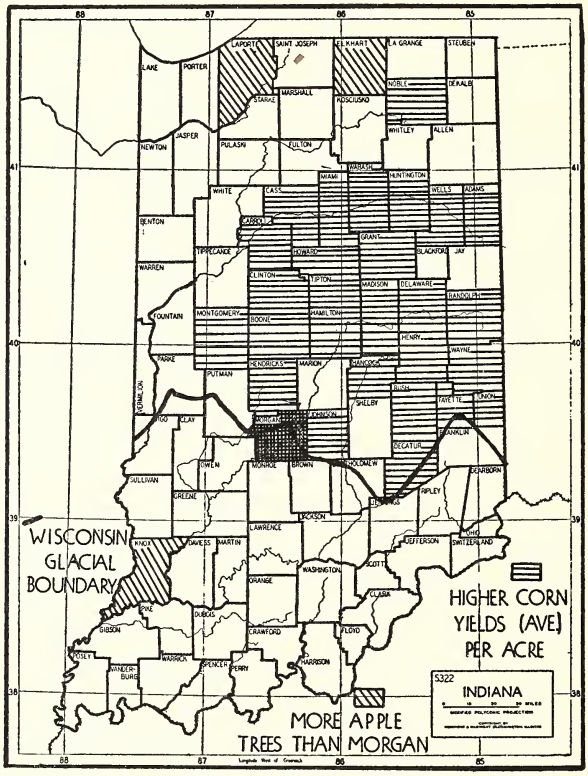

Fig. 2. Morgan County's rank in corn yields (1934-43 average) and number of apple trees (1940 census). Corn yields compiled from Annual Crop Summaries prepared by Department of Agricultural Statistics, Purdue University.

For the rough southern part of the County, average yields were comparatively low (44 bushels); the corn acreage there is small.

High yields: A study of corn yields of 100 bushels or more from 1934-1944 made by farmers who have entered the five-acre contests of the Indiana Corn Grower's Association reveals further notable influences of glaciation upon agricultural production. Within Morgan County climatic contrasts are almost absent; therefore the distribution of high yields are explained by other factors. Figure 3, showing the

distribution of high yields, shows a concentration in two areas: (1) glacial Lakes Eminence and Quincy and (2) the first and second White River Bottoms. Five-sixths of the high yields were made on soils that make up only one-sixth of the total area. Most of the remaining high yields were made on creek bottom soils. Approximately one-half of the soil area having exceptional yields are subject to overflow, which strongly suggests that Morgan County would rank much lower but for the alluvial materials transported from Wisconsin till areas. For 1934-44 Morgan ranks in the upper one-third among Indiana counties in high yields but has a slightly lower position than for average yields (Fig. 2). That Morgan County is surpassed by such counties as Martin, Davies,

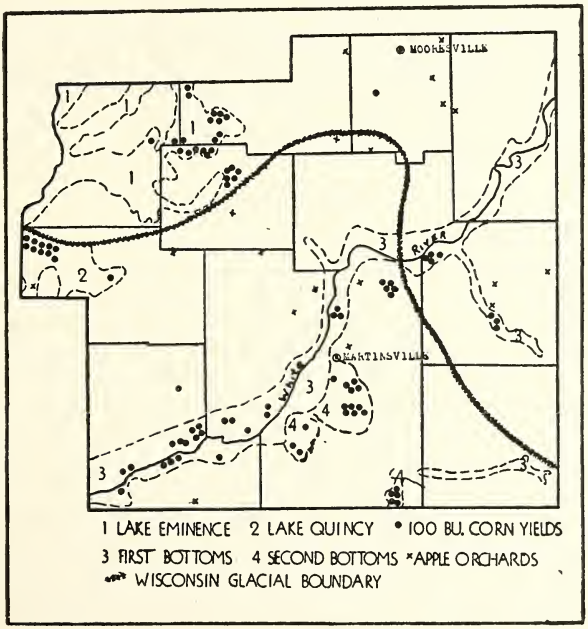
MOORESVILLE
MARTINSVILLE
WHITE RIVER
1 LAKE EMINENCE 2 LAKE QUINCY • 100 BU. CORN YIELDS
3 FIRST BOTTOMS 4 SECOND BOTTOMS *APPLE ORCHARDS
WISCONSIN GLACIAL BOUNDARY

Fig. 3. Location of high corn yields (1934-44) and commercial apple orchards in Morgan County.

Green, and Clay in the number of 100 bushel yields, but that these counties have considerably lower average yields, further illustrates the production capabilitis of alluvial soils.

About one-half of the high yields were produced on the Genesee, Eel, Toledo, and Fulton soils. The Martinsville, Philo, Russell, and Crosby soils have also produced exceptionally high yields. All of these soils are better than average, and no 100 bushel yields were obtained on soils below the average in productivity. These more productive soils are all directly or indirectly related to glaciation. The lacustrine deposits in the northwestern part of the County have made especially fertile soils once they were drained. Some of this area is subject to overflow which

has aided in maintaining fertility. The White River bottom soils have been transported from the fertile Wisconsin drift area, which largely explains their fertility. The upland soils formed from Illinoian drift are less fertile than those in the Wisconsin drift area; however some of the bottom soils formed mainly from transported Illinoian drift materials have contributed high yields.

As most of Morgan County's soils lack sufficient natural fertility for 100 bushel yields, considerable commercial fertilizer and lime are used. Questionnaire returns reveal that commercial fertilizer was used in producing three-fourths of the 100 bushel yields, and lime had been applied to one-half of the fields. Significant contrasts in the use of fertilizers are apparent. In the First White River bottoms only one-eighth of the high yields were grown on fertilized fields. On the Second bottoms, beyond the range of floods, practically all of the high yields were produced on fertilized fields. Similarly, the 100 bushel yields on upland soils and on the lacustrine soils are commonly fertilized. Hence the distribution of high yields in Mogran County correlates closely with glaciation.

Apple Orchards

Morgan County's high rank in apple production has an interesting relation to geographic factors. Only three Indiana counties surpass Morgan in the number of apple trees of bearing age (Fig. 2). Three factors have been especially significant in promoting orchards: (1) sufficient slopes to permit air drainage, (2) soils of adequate fertility on slopes and ridges, and (3) good location in respect to markets and shipping facilities. Figure 3 shows the location of the principal apple orchards. Most of the orchards are located on the more rolling parts of the Till Plain or near the Wisconsin Glacial Boundary. This distribution suggests that soils above average in fertility found in conjunction with slopes sufficient to provide air drainage are an important requirement for good orchard sites in a region having considerable frost hazard. Morgan County has numerous locations wth favorable air drainage, but many of these lack fertile soils. The orchards are concentrated on the Russell, Crosby, Miami, and the better phases of the Cincinnati soils, all of which are relatively good upland soils.

An exceptionally favorable orchard site is situated in the north central part of the County just south of the glacial boundary. Here an upland area is bordered on the north by a steep slope which was once the shore of Lake Eminence. Other good orchard sites are on the rolling uplands to the southeast, west, and southwest of Mooresville. The County's largest orchard is located west of Mooresville where rolling uplands grade into the almost level Till Plain to the north and into the rough morainic area to the south. While differences in elevation are not great, there are sufficient contrasts to lessen appreciably the hazards of late spring frosts. Glaciation has been largely responsible for the topography which permits good air drainage and soils.

Conclusions

Four conclusions are: (1) Land assesment values in Morgan County correspond closely to differences in topography and soils. Location is a secondary factor. (2) Land values and average corn yields increase northward with increase in amounts of glacial till. (3) High corn yields are heavily concentrated in the glacial lakebeds and river bottoms; both of which have especially benefited from glaciation. (4) The combination of above average soils and favorable air drainage, and proximity to Indianapolis with its large market largely explains Morgan County's high rank in apple production; again the glacial influence is highly significant.

Uncommon Occurrences of Some Southern Illinois Minerals

S. M. McClure, Eureka College, Eureka, Illinois

Near the glacial border in southwestern Illinois, Pennsylvanian and Mississippian strata form the surface rocks, and outcrops are numerous throughout the region. Normally, none of these formations are interestingly mineralized and the occurrence of a few minerals, uncommon at least in this region, has been noted incidental to other field work and is recorded in this paper.

While the Illinois fluorspar mines are among the largest producers in the nation, the occurrence of this mineral is limited to a relatively small area in Hardin and Pope counties affected by a local igneous intrusion. The occurrence of fluorite in limestone at locations not apparently connected with igneous activity is well known but is not a particularly common mode of occurrence, especially in the southewestern part of Illinois.

While the mineral has previously been recorded in the limestones near St. Louis, Missouri, (1) as disseminated grains, fluorite crystals and crystallized masses as large as a watch have more recently been found in Illinois in a Mississippian limestone, tentatively identified on the basis of a few badly weathered corals and other inconclusive field evidence as the St. Louis formation of the Valmeyer series. The location is in Monroe County near the village of Maeystown.

The mineral occurs in two adjacent outcrops of microcrystalline chert or quartz, in and on a structure that in some features resembles an ancient coral reef. No igneous activity is known to have taken place nearer than that of the Iron Mountain area some sixty miles to the southwest in the Missouri Ozarks.

Imperfectly developed cubic crystals, few of which reach half an inch in size, make up the bulk of the crystalline mass; typical octahedral cleavage is shown in most of the specimens. The amber color of the mineral may be due in part to hydrocarbon inclusions as it becomes somewhat lighter on gentle heating, under the argon lamp, however, the crystals show no fluorescence.

Associated with the fluorite in this locality is a platy barite of a white to gray color. No good crystals of the mineral were found and it is quite unlike the better known Washington, Missouri, barite in general appearance. The density of the mineral, taken as an average of several determinations, is 4.32, a bit lower than the accepted value of 4.5 for pure barite.

The massive microcrystalline chert or quartz is grayish white in color and contains coral fossil fragments. Both the fluorite and the

barite occur in crevices in the chert but in such a way that it is difficult to tell whether these minerals were deposited at the same time as the chert or later. No millerite, as was noted (1) in the St. Louis occurrence of fluorite, was seen at either outcrop.

Aside from mention by the writer in a paper for a mineral collectors' journal (2), this occurrence seems unrecorded previously in the literature of the area.

A somewhat unique ferriferous dolomite has been found, aparently as a lining of solution cavities in the Lower Okaw formation of the Chester series (3) in southwestern Randolph County west of Kaskaskia River. Specimens of this mineral are gray to tan in color but are frequently covered with a heavy rusty incrustation on the typical dolomite crystal surfaces.

Otherwise the characteristics are those of a typical dolomite; the hardness lies between 3.5 and 4, slightly greater than siderite, and the density is about 2.9. The luster is best described as sub-vitreous with an occasional faint greenish tinge; this may be due to a surface film of oxidized material. The mineral, except in very thin sections, is practically opaque. Typical curved crystal outlines, coated with the incrustation of iron compounds, are numerous but the cleavage is too indistinct to show consistent angles.

Chemical analysis shows the presence of calcium, magnesium, and ferrous carbonates; little or no manganese is present. This composition is similar to that given for ankerite, the ferriferous variety of dolomite. (4)

While both pyrite and marcasite are abundant in the Pennsylvanian coals and shales, the latter mineral is not, in this part of the Illinois coalfield, in the discoidal form, commonly called marcasite "suns". This type of marcasite has been found to occur in the roof shale of the No. 6 coal, the Belleville coal, in a mine near O'Fallon in St. Clair County. The radiating discs are typical marcasite in structure (5), color, and chemical reactions. So far as is known, this occurrence is limited to the one portion of a single mine in the area.

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4. Hurlbut, C. S. Jr., 1944. Dana's Manual of Mineralogy, p. 227.
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The Daily Weather Map and Its Major Functions

G. David Koch, Indiana State Teachers College

Mark Twain once remarked, "everybody talks about the weather but nobody does anything about it." That may have been true in the days of Mark Twain but hardly is a truism today. Much is being done about the weather, especially in regard to learning more about the physical reactions which take place in the upper atmosphere and which are in turn largely responsible for the great varieties of weather as experienced in Indiana.

The increased knowledge of the physics of the air has made possible, among other things, a more accurate forcast of weather activities. Weather phenomena and changes do not just occur; rather they are the result of orderly and explainable physical reactions which take place in the gaseous envelope which surrounds our planet. Whenever one is able to forecast accurately these physical reactions and to forsee their movements across the country, accurate weather predictions are possible.

Among the numerous weather phenomena which result from physical reactions in the atmosphere are: air masses, fronts, wind, temperature, pressure, humidity, clouds, dewpoint and precipitation. The weather forecaster, when making a prediction, must consider each of the above mentioned elements and evaluate the significance of each phenomenon upon future weather. In order to evaluate the elements the forecaster must have a clear and concise mental picture of each weather phenomenon at his station and all surrounding stations. This picture he secures by means of the daily weather map, a synoptic chart, which shows the existing weather conditions over the entire United States. The data, which is plotted on the synoptic map, is secured at approximately 200 weather stations at exactly the same hour or 1:30 a.m. Eastern Standard Time. A complete daily weather map of the United States is made at each of the 200 stations. Numerous stations publish the map for local distribution. The Washington D. C. map is printed for country-wide distribution and is available to anyone at a nominal charge. Institutions which post the map for public use receive the map free of charge.

Although a discussion of the methods followed in securing weather data and procedures employed in drawing the weather map are intensely interesting, the purpose of this paper is to explain the map itself and discuss its numerous functions. These functions are of great importance to the weather forecaster, airplane pilot, farmer, fruitgrower, nurseryman, those engaged in water and land transportation and the average layman. Numerous other functions might be enumerated, but the list stated above emphasizes the importance of the daily weather map.

Prior to the summer of 1940 the Weather Bureau was administered by the United States Department of Agriculture. However, in August, 1940, the Weather Bureau was transferred to the Department of Commerce where it still remains. In its new environment the Bureau gained new impetus. The weather map was greatly improved in regard to the information presented. Figure 1 shows a portion of the Daily Weather Map as published prior to August 1940 and figure 2 is a reproduction of a part of the map after the Bureau was transferred to the Department of Commerce.[1]

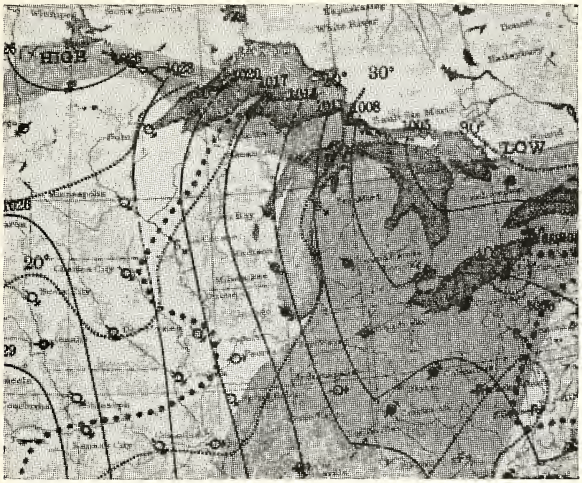


Fig. 1. A section from the United States Weather Map as it appeared prior to August 1940.

A comparison of figures 1 and 2 shows readily the increased amount of data presented on the latter figure. On the older map wind direction, amount of cloudiness, kind of precipitation, temperature and barometric pressure were shown. Areas of high and low pressure were also indicated on the map. Wind directions were shown by arrows, which flew with the wind. The degree of cloudiness at each station was shown by circles which were blocked out according to the amount of sky obscured by clouds. Kinds of precipitation were indicated in the station circle by upper case letters as "R" for rain and "S" for snow. Dashed lines, called isotherms, and drawn through stations having equal temperature, were used to show temperature. Light continuous lines, called isobars, were drawn through points of equal sea-level pressure and indicated barometric pressure. The isobars also marked the shape and extent of the areas of high and low pressure.

[1] All of the maps and charts presented in this paper are reproduced from the Daily Weather Map and are used by written permission from the United States Weather Bureau.

The Daily Weather Map, as described, served for many years as a basis of weather forecasting and served its purpose well. However with a rapidly mounting interest in air traffic and automobile transportation in the 1930's a demand for more weather information steadily increased. The development of new and more precise weather instruments also opened up a wider knowledge of the physical reactions of the atmosphere and these made possible more accurate and extended weather predictions. In order to present a synoptic picture of the more extensive data available a new type of daily weather map was made. Figure 2 presents a reproduction of the new type of Daily Weather Map as now published.

Meterological data secured at approximately 200 selected weather stations are included on the present map. This information includes di-

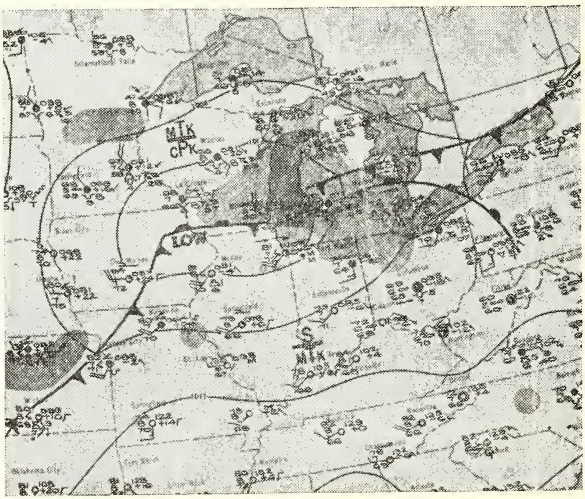


Fig. 2. A section from the United States Weather Map as it is produced at present.

rection and velocity of the wind, barometric pressure reduced to sea level, amount and type of precipitation, present and past weather, temperature, dew point, kind and amount of clouds, visibility and the pressure tendency. Other meteorological data of infrequent occurrence such as tornadoes or hailstorms are also indicated as needed.

In order to present the data enumerated above in an orderly and easily readable manner each is shown by means of figures or symbols and always occupy the same relative position around the station circle. The station circle with all of its accompanying data is referred to by the meteorologist as the Station Model. (Fig. 3.)

Wind direction is denoted by a shaft extending from the station circle toward the direction from which the wind blows. The number and lengths of feathers on the shaft indicates the velocity of the wind. Table 2 on figure 4 shows the symbols used to indicate wind velocity.

Figure 4 is a partial reproduction of a complete explanation found on the reverse side of the Daily Weather Map. Other tables of symbols show Barometric Tendencies, Cloud Symbols, Station Model, Present Weather Symbols and an explanation of Fronts and Air Masses.[2]

Barometric pressure at sea level is shown in figures at the upper right of the station model. The pressure is stated in "tens", "units" and "tenths" of millibars, the initial 9 and 10 being omitted. On figure 3 the pressure is 247 which means a barometric reading of 1024.7 millibars. The net amount of barometric change in the 3 hours preceding that of observation is shown immediately to the right of the station circle. In figure 3 the change has been 2.8 millibars; the + sign indicates the

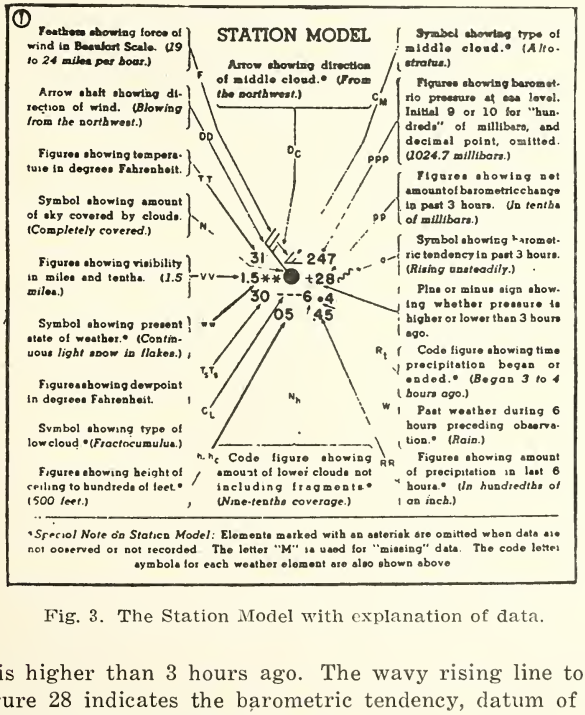

STATION MODEL
Feathers showing force of wind in Beaufort Scale. (19 to 24 miles per hour.)
Arrow shaft showing direction of wind. (Blowing from the northwest.)
Figures showing temperature in degrees Fahrenheit.
Symbol showing amount of sky covered by clouds. (Completely covered.)
Figures showing visibility in miles and tenths. (1.5 miles.)
Symbol showing present state of weather.* (Continuous light snow in flakes.)
Figures showing dewpoint in degrees Fahrenheit.
Symbol showing type of low cloud.* (Fractocumulus.)
Figures showing height of ceiling to hundreds of feet.* (500 feet.)
Arrow showing direction of middle cloud.* (From the northwest.)
Code figure showing amount of lower clouds not including fragments.* (Nine-tenths coverage.)
Symbol showing type of middle cloud.* (Altostratus.)
Figures showing barometric pressure at sea level. Initial 9 or 10 for "hundreds" of millibars, and decimal point, omitted. (1024.7 millibars.)
Figures showing net amount of barometric change in past 3 hours. (In tenths of millibars.)
Symbol showing barometric tendency in past 3 hours. (Rising unsteadily.)
Plus or minus sign showing whether pressure is higher or lower than 3 hours ago.
Code figure showing time precipitation began or ended.* (Began 3 to 4 hours ago.)
Past weather during 6 hours preceding observation.* (Rain.)
Figures showing amount of precipitation in last 6 hours.* (In hundredths of an inch.)
31
247
1.5**
+28
30
-6
05
45
*Special Note on Station Model: Elements marked with an asterisk are omitted when data are not observed or not recorded. The letter "M" is used for "missing" data. The code letter symbols for each weather element are also shown above

Fig. 3. The Station Model with explanation of data.

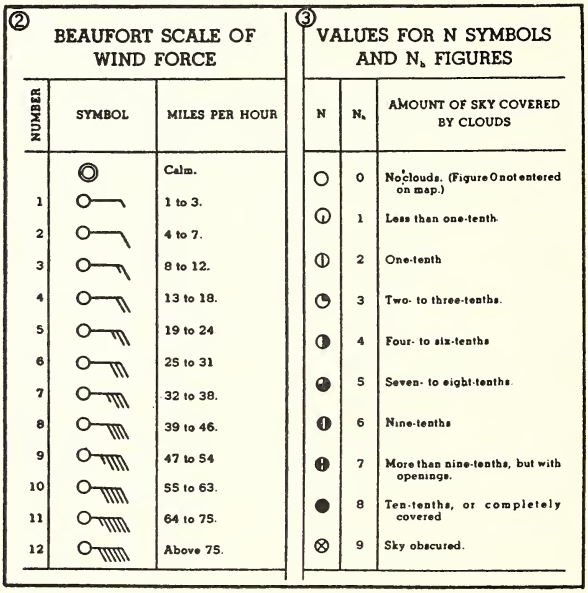
pressure is higher than 3 hours ago. The wavy rising line to the right of the figure 28 indicates the barometric tendency, datum of basic significance in weather forecasting.

Within the station circle a cloudiness symbol is drawn to indicate the amount of sky obscured by clouds. The portion of the circle which is blacked out shows the per cent of sky obscured. Table 3 in figure 4 presents the cloudiness symbols and percentage value of each.

The state of weather current during the period of observation is shown by a symbol immediately to the left of the station model. In case

[2] A complete explanation of the code symbols used on the Daily Weather Map may also be found in: (1) Haynes, C. B., Meteorology for Pilots, Bulletin 25, United States Printing Office, Washington, 1943. (2) Numerous good texts on Meteorology also show the symbols used on weather maps.

the weather is fair or the cloudiness symbol in the station circle adequately describes the current weather the weather symbol is omitted. One hundred three states of weather are classified by the Weather Bureau. These symbols have been drawn to represent actual weather conditions as accurately as possible. For example, a "." for rain; an "*" for snow and a "," for drizzle are typical. The number and arrangement of symbols represent the intensity of precipitation. In the station model shown in figure 3, the present state of the weather is shown thus "**." This symbol indicates continuous light snow in flakes. On the face of the map (Fig. 2) black dot shading shows areas where precipitation was falling at time of observation.



② BEAUFORT SCALE OF WIND FORCE

NUMBER	SYMBOL	MILES PER HOUR
		Calm.
1		1 to 3.
2		4 to 7.
3		8 to 12.
4		13 to 18.
5		19 to 24
6		25 to 31
7		32 to 38.
8		39 to 46.
9		47 to 54
10		55 to 63.
11		64 to 75.
12		Above 75.

③ VALUES FOR N SYMBOLS AND N_h FIGURES

N	N_h	AMOUNT OF SKY COVERED BY CLOUDS
	0	No clouds. (Figure 0 not entered on map.)
	1	Less than one-tenth.
	2	One-tenth
	3	Two- to three-tenths.
	4	Four- to six-tenths
	5	Seven- to eight-tenths.
	6	Nine-tenths
	7	More than nine-tenths, but with openings.
	8	Ten-tenths, or completely covered
	9	Sky obscured.

Fig. 4. A part of the reverse side of the Daily Weather Map, the whole of which presents a complete explanation of the data appearing on the face of the map.

Kind of weather that has been experienced during the 6 hours preceding the observation is shown to the lower right in the station model. Past weather, time precipitation began or ended and amount of precipitation are entered. Whenever the letter "T" appears in place of the measured amount of precipitation, less than 0.01 of an inch has fallen. The amount is then recorded as a trace.

To the upper left of the station circle figures indicating the temperature in degrees Fahrenheit are entered. Directly below the state of the weather entry, figures showing the dew point in degrees Fahrenheit appear. On the weather map only two isotherms, lines connecting points of equal temperature, are drawn. Dashed lines, labeled Freezing, and

dot-dash lines, labeled Zero, are drawn through points where the current temperature is 32° F. or 0° F., respectively. The freezing and zero isotherms separate areas in which temperatures are above and below 32° F. or 0° F.

To the left of the state of the weather symbol on the station model figures are entered which give visibility in miles and tenths of miles. In figure 3, for example, visibility is one and five tenths miles.

Directly below the station circle a symbol is entered to indicate type of low clouds. If no such clouds exist no symbol is used. Below the low cloud symbol figures are placed to show the height of the ceiling to hundreds of feet. Directly above the station circle is entered a symbol to indicate type of middle cloud. Above the middle cloud symbol is placed the high cloud symbol. No such entry appears on figure 3 since high clouds were nonexistent or not visible. A study of actual cloud formations and the symbols used to show these clouds indicate the symbols have been drawn to correspond closely with cloud shapes.

On the face of the weather map (Fig. 2) appear the words "High" and "Low". These terms indicate centers of high and low barometric pressure of air masses. Air masses are classified into several different types according to their origin and basic characteristics. These masses are represented on the weather map by labels such as mTk, cPw and mTw. The label mTk is explained as follows: m indicates the mass formed over the ocean; T means it formed in tropical latitudes and the letter k shows the temperature of the air mass is colder than the surface over which it is moving. cPw may be explained as follows: c = formed over a continent; P = polar latitudes and w = warmer than surface.

Heavy lines called "Fronts" separate air masses of different characteristics. The front bounding the forward edge of a cold air mass is known as a cold front. It is indicated on the weather map by placing triangular points on the "front" line. Fronts preceding warm masses of air are called warm fronts and are shown by half circles on the map. The side of the line on which the triangles or half circles are placed indicate the direction in which the front is moving. Frequently a cold front overtakes a warm front. The line where such a junction occurs is called an occluded front. The boundary between two air-masses which show little tendency to move is known as a stationary front.

A front which is disappearing or decreasing in intensity is labeled "frontolysis", while a front that is forming or increasing in intensity is labeled "Frontogenesis".

On July 1, 1944, more meteorological data was added to the face of the Daily Weather Map in the form of three maps. In the lower left corner of the sheet is printed a weather map which shows the pattern of isobars and location of existing fronts for an observation made 12 hours previous to that of the large weather map or at 1:30 p.m. of the previous day. In those areas where precipitation was falling at 1:30 p.m. a black dot shading is used. A comparison of the 1:30 p.m. map and the 1:30 a.m. map reveals how the pattern of air masses and fronts has changed in the previous 12 hours. Such information is basic in formulating accurate forecasts of future weather.

Another small map is printed in the lower center part of the map. This map shows precipitation areas and amounts which occurred during the 24-hour period prior to the observation time of the large weather map, or 1:30 a.m. Areas where precipitation occurred are shown by black dot shading, while figures indicate the amount of precipitation in hundredths of an inch. The letter "T" appearing on the map indicates a trace of precipitation. There are 168 weather stations on the map.

In the lower right hand corner of the Daily Weather Map is a small map showing the maximum and minimum temperatures which occurred at the 168 selected weather stations in the United States during the 24-hour period ending at 1:30 a.m. The upper figure at each station is the highest temperature and the lower figure is the lowest temperature recorded during the 24-hour period. The black dot shaded portions cover areas where the temperature at 1:30 a.m., or time of observation for the large map, is at least 10 degrees higher or lower than the temperature was 24 hours previous, or at 1:30 a.m. the previous day. Should the letter "M" appear on the map, that indicates missing data for that station.

The Daily Weather Map is a basic tool for the meteorologist. A succession of three or four maps presents a continuous picture of weather changes. The forecaster is able to determine the speed of air masses and fronts; to determine whether an individual pressure area is deepening or becoming more shallow; whether a front is increasing or decreasing in intensity. The meteorologist is also able to determine whether an air mass is retaining its original characteristics or taking on those of the surface over which it is moving. Although the above stated information is only a portion of that necessary in taking accurate weather predictions, individually and collectively it is basically essential. Of course, all the data entered on the Daily Weather Map has its specific function in weather forecasting. Thus, it becomes clear that the most significant function of the map is that of presenting a synoptic picture of the physical conditions existing in the atmosphere at a given time. This picture is then employed by the meteorologist as an aid in forecasting future weather.

As stated earlier in this paper a detailed discussion of the procedures followed in making the Daily Weather Map would be interesting and informative. Equally interesting would be the methods used in making weather predictions. However, such descriptions are not the functions of this discussion, and must therefore be omitted.

Although the primary function of the Daily Weather Map is its use by the meteorologist it could be of much greater value to the average citizen. However, the laymen seldom becomes well enough informed to interpret or to gain much value from the map. This is indeed unfortunate since as has been shown in the foregoing pages the map is hardly as complicated as it may first appear. The average person would gain more acquaintance with the map were it more widely printed in daily newspapers and used by more business concerns.

In November, 1944, a new feature was added to the weather map which is of prime importance to various groups of people. Several

times a week, special charts are printed on the reverse side of the weather map in place of the usual "Explanation of the Weather Map," as already shown in figure 3. An example of charts found on the reverse side of the Daily Weather Map is shown in figure 5.

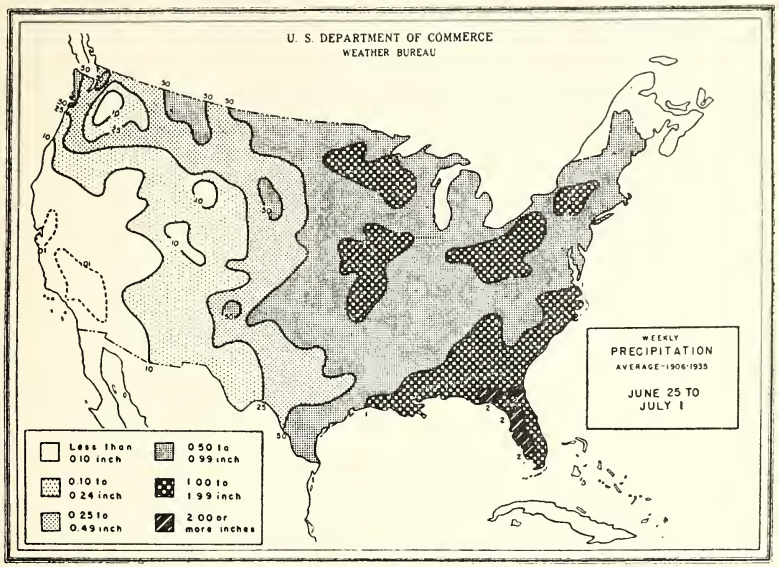


Fig. 5. An example of the special information which appears frequently on the reverse side of the Daily Weather Map.

Since this new service was begun nearly two years ago, 194 charts have been presented and discussed to date. (Oct. 1, 1946) These charts may be divided into thirty-four subject matter groups as follows:

1. Temperature charts
2. Precipitation charts
3. Wind and Sunshine charts
4. How the Daily Weather Map is Made
5. How Hurricanes are Shown on Weather Maps
6. Spring Weather and the Home Gardener
7. Cloud Types and Pictures
8. It Isn't the Heat, It's the Humidity
9. Tornadoes
10. To Alaska by Air
11. River and Flood Forecasting Service
12. Weather and Vacations
13. Minute Men in Storm and Flood
14. The Fruit-Frost Service
15. The Weather and Cranberries
16. Raisins and Rain Warnings
17. Weather and Bananas

18. Grain Spoilage and Rainfall
19. Weather in Walla Walla
20. Fire-Weather Forecasting
21. Forecasting Storms on the Great Lakes
22. Weather and the Railroad
23. Storms and Shipping
24. Aviation and the Weather Map
25. Meteorological Service to Airways in the United States
26. A Series of Analyzed Charts
27. Pilot Balloon Stations in the United States and Alaska
28. Radiosonde Stations in the United States and Alaska
29. Ice Storm of December 27, 1944
30. Meaning of Degree Days
31. The Structure of Fronts
32. Pilot Balloon Observations
33. The Beaufort Wind Scale
34. The Ohio River Flood of Mar. 5-6, 1945

Certain charts are presented each month of the year, such as the charts showing temperature, wind, and sunshine, and precipitation. A part of the latter chart for June 1946 is reproduced in figure 5. Special charts showing a detailed analysis of local unusual storms are frequently presented. Typical titles of such charts are: The Cold Wave of Jan. 7-9, 1945; The Midwest Storm of Feb. 21-22, 1945; Pre-Cold Front Weather, May 7-8, 1945; Heavy Rains in Eastern United States, July 15-19, 1945; The Duststorm and Blizzard in the Midwest, Feb. 5-6, 1946 and The Spring Snowstorm in the Rockies, May 9-10, 1946. Two and three sets of charts are often used to explain these unusual phenomena. Because of the wide-spread interest created by certain charts, they are frequently reprinted. For example, the following charts have appeared at least twice: "Cloud Types and Pictures", "Tornadoes", "Spring Weather and the Home Garden", and "It Isn't the Heat, It's the Humidity'.

An examination of the titles and subject matter of the charts indicates that certain ones would be of greater interest to one group of people while other charts would appeal more to other groups. In the list of thirty-four subjects stated earlier, it is obvious that the first thirteen titles would be of interest to the general public. However, subjects fourteen to nineteen inclusive, would appeal more to the agriculturalist. On the other hand subjects twenty to twenty-five inclusive would hold special interest for those groups associated with the various types of transportation.

Further examination of the titles listed should indicate that many will hold considerable interest for several groups of people. All of the charts are informative and easily understood. The Weather Bureau uses special care in preparing the material appearing on the charts so that it will be as non-technical as possible. It is to be hoped that the Weather Bureau will continue to offer these valuable charts for use by

the general public. The charts add materially to the value of the Daily Weather Map itself.

Only a few statements are needed to summarize this discussion. The Daily Weather Map is a synoptic chart of the weather conditions as they exist over the United States at 1:30 a.m. Eastern Standard Time. The data used in preparing the map is secured from approximately 200 selected weather stations and located in all parts of the country. The map presents a picture of the distribution of air masses and fronts for the time of observation. At each weather station is placed a station model in which appears meteorological data pertinent to the forecaster in making weather predictions.

On the back of the Weather Map there appears frequently special charts which present information pertinent to farmers, transportation groups, fruit growers, meteorologists and the general public. The charts are presented in a clear and simple manner and are highly informative.

The Daily Weather Map and the special charts offer to the laymen a valuable service relative to the weather both past, present and future. It is the obligation of each well informed citizen of the United States to become acquainted with this service and profit from it.

The Influence of Coarseness of Grain on the Lifting Effect of Quicksand

ERNEST RICE SMITH, DePauw University

If the lifting effect of quicksand is a combination of the buoyancy of the water and the upward moving currents of the water (3) the lifting effect of a coarse quicksand should be greater than that of a fine quicksand. Samples of fine sand and coarse sand were placed in the quicksand device, as designed by H. T. Jenkins (2). When upward currents of water were developed with sufficient velocity to make the sand "quick", the lifting effect of the quicksand was measured (a) by an hydrometer and (b) by the line to which a wooden model (Fig. 1) was lifted.

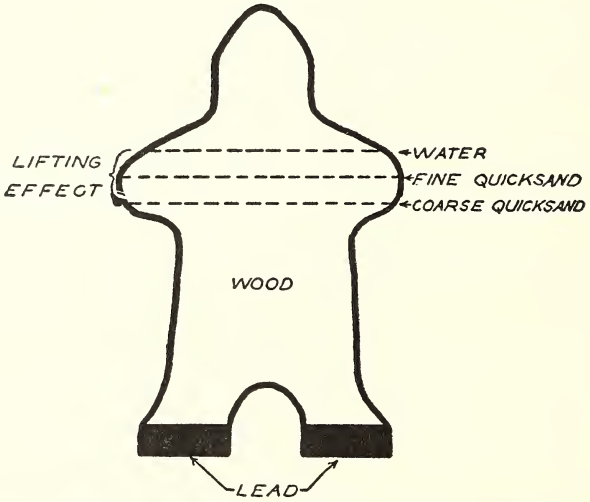


Fig. 1. Comparison of the Lifting Effect of Water, Fine Quicksand and Coarse Quicksand.

The fine quicksand raised the wooden model to the line as shown in figure 1 and exerted the same lifting effect as a liquid with a specific gravity of 1.156 as shown by the hydrometer. Analysis of coarseness of grain of the fine sand (Fig. 2) indicates somewhat greater variability than would be expected in a quicksand which had been exposed to rising currents of water for any great length of time. This sand was artificially crushed and washed Mansfield Sandstone from the abandoned quarry of the American Glass Sand Company, at Fern, Putnam County, Indiana. In a spring with velocity sufficient to lift apart sand grains of between 20 mesh and 60 mesh, doubtless sand grains between minus 200 mesh

and 60 mesh would be carried away, resulting in a more uniform diameter of actual quicksand grains. The small number of grains above 20 mesh, on examination with a hand lens, appeared to be finer sand grains cemented into larger aggregates by limonite. In the preparation of the

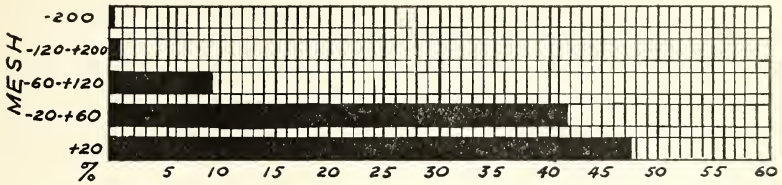


Fig. 2. Grain Analysis of the Fine Quicksand.

glass sand, these had merely not been broken down as completely as the rest of the grains.

The coarser sand studied was a mortar sand from Big Walnut Creek near Greencastle, Putnam County. The distribution of its grain size is shown in figure 3. As in the case of the finer sand, doubtless there is much greater variability of size than would be shown had this sand been exposed to rising currents for a much longer time. Doubtless sand etc. finer than 20 mesh would have been completely carried away. Both of these sands, although very "quick" in the presence of rising currents

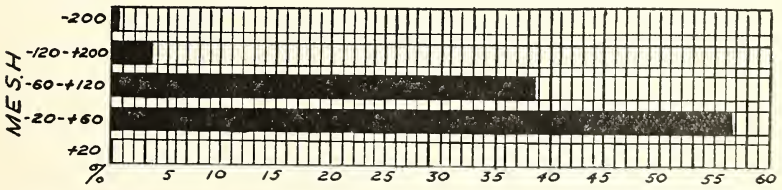


Fig. 3. Grain Analysis of the Coarse Quicksand.

of sufficient velocity, were very compact when dry or moist and showed but little tendency to roundness under a microscope, although no effort was made to determine the "roundness" according to the system suggested by Cox. (1, p. 180)

This coarser sand, when made "quick" by rising currents of water, showed a lifting effect equal to the buoyancy of a liquid with specific gravity of 1.70 and lifted the wooden model to the line shown in figure 1.

The evidence derived from the study of the lifting effect of these two sands is considered to support the suggestion previously made that the lifting effect of a quicksand is a combination of the buoyancy of the water and its upward movement.

References Cited

1. Cox, E. P., 1927. A Method of Assigning Numerical and Percentage Values to the Degree of Roundness of Sand Grains. J. Paleontology, **1**:179 et seq.

2. Smith, Ernest Rice, 1946. Sand. Proc. Ind. Acad. Sci., **55**:121-143.

3. Smith, Ernest Rice, 1946. The Lifting Effect of Quicksand. Ohio Jour. Sci,. **46**:327.

A Study of the Supposed Suction Effect of Quicksand

ERNEST RICE SMITH, DePauw University

It would seem a sheer waste of time to study a supposed suction effect of quicksand in view of the evidence brought out in the preceding paper on "The Influence of Coarseness of Grain on the Lifting Effect of Quicksand." Yet even in the presence of data indicating a lifting effect equal to the buoyancy of liquids with a specific gravity of 1.156 to 1.7, still the question arises in the minds of certain geologists—Will not hollows in the human body and in clothing of victims develop such a partial vacuum as to make it relatively difficult to escape from quicksand once a person or other animal is engulfed? Experience with a large

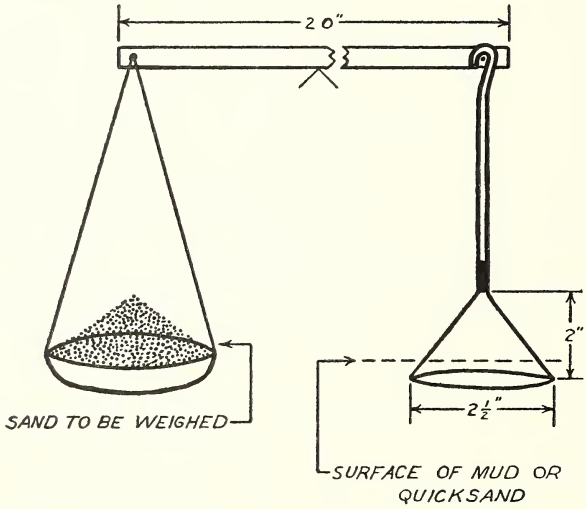


Fig. 1. Apparatus for Comparison of the "Suction Effect" of Mud and Quicksand.

crystal of garnet without such hollows was considered to be indecisive, although it could be extricated so much more easily from sand, made "quick" by rising currents, than from the same sand, merely damp.

To study the influence of such points of partial vacuum the device as depicted in figure 1 was constructed. The inverted funnel on the right, after the opening at the top of the funnel had been fused tightly, was partially immersed in a sticky clay mud and in the two quicksands discussed in the previous paper. At the beginning of each test, the beam was placed on the fulcrum so that the beam was horizontal. Then

sand was poured slowly into the pan until the funnel was pulled out of the immersing material. The amount of sand required was then weighed to give an indication of the suction effect of the immersing material, clay mud or various coarsenesses of quicksand. The average required weight of sand to lift the funnel from the mud was 152.7 gms. There is possibly some variation due to variability of viscosity of the mud which would lose some water due to evaporation in the drier-than-Yuma atmosphere of the laboratory. The amount of sand required to draw the funnel from the fine quicksand was but 16.5 gms., average of three tests. With the coarse quicksand, the lifting effect was so great that the bar could not even be set horizontal.

As a result of these studies, the writer believes that there is no suction effect in quicksand comparable to that in mud, and that the coarser the quicksand the less the so-called suction effect.

An Unusual Aspect of the Contact Between the Mooretown Sandstone and the Paoli Limestone

PRESTON MCGRAIN, Indiana University

The purpose of this paper is to describe an unusual aspect of the contact between the Mooretown sandstone and the underlying Paoli limestone observed by the writer in Crawford County, Indiana. The outcrop described below is located in a road cut along Indiana Highway 62, Section 33, T. 3 S., R. 2 E., about two miles northeast of the town of Leavenworth.

The Mooretown is the third member of the Chester series, Upper Mississippian, in Indiana, being preceeded by the above mentioned Paoli limestone and a thin, limy sandstone representing the Aux Vases sandstone of the Illinois section. However, at the locality described in this paper the Aux Vases is not present. The Paoli here rests upon a brecciated limestone bed which tops the Ste. Genevieve limestone.

The Mooretown formation in Southern Indiana is a sandstone, shale, or sandstone and shale, often containing one or two thin seams of coal. The sandstone is generally fine to medium grained, cross bedded, and iron stained, and varies from friable to well-cemented stone. Markings of the plant fossil *Stigmaria* are frequently present and serve to characterize this sandstone formation. The thickness varies from 10 or 12 to 40 feet or more on the outcrop and generally averages 20 feet. It rests upon the Paoli in a more or less conformable manner, the contact usually being flat or slightly undulating.

At the locality described in this paper the Mooretown possesses most of the features usually found at other outcrops. The basal portion of the formation consists of a three foot bed of angular and medium grained, iron stained, well-cemented sandstone. Along the full length of the exposure in the road cut the plant fossil *Stigmaria* occurs at the top of this bed. The remainder of the Mooretown is composed of ten feet of soft gray and tan shale. A thin smut streak was observed at the base of the shale section overlying the *Stigmaria* zone at a position normally occupied by at thin coal bed. The boundary between the Mooretown and the subjacent Paoli, instead of being marked by the characteristic flat or moderately undulating surface, is represented here by a number of cylindrical depressions in the Paoli limestone that are filled with sands belonging to the Mooretown. Remnants of four sandstone columns that filled these depressions in the Paoli were observed by the writer (Fig. 1). At one other place on the face of the road cut sand and sandstone were cemented on the weathered limestone outcrop in sufficient quantity to strongly suggest the former presence of still another sandstone column. These sandstone columns, probably best described as natural casts, are ten to twenty-one inches in diameter and

penetrate the Paoli three to five and one-half feet or possibly more below the top of that formation. Like the sandstone bed above, the columns are composed of cemented, medium grained, iron stained sands.

Referring to figure 1, Column A is fourteen inches in diameter and three feet long. Only a portion of Column B remains, and that portion appears to be undergoing rapid disintegration. The lowest visible standstone was five feet below the main body of the Mooretown; the actual base appears to be still lower. The remnant of this column was twenty-one inches in diameter. Column C (Figs. 1 and 2), the smallest of the group,

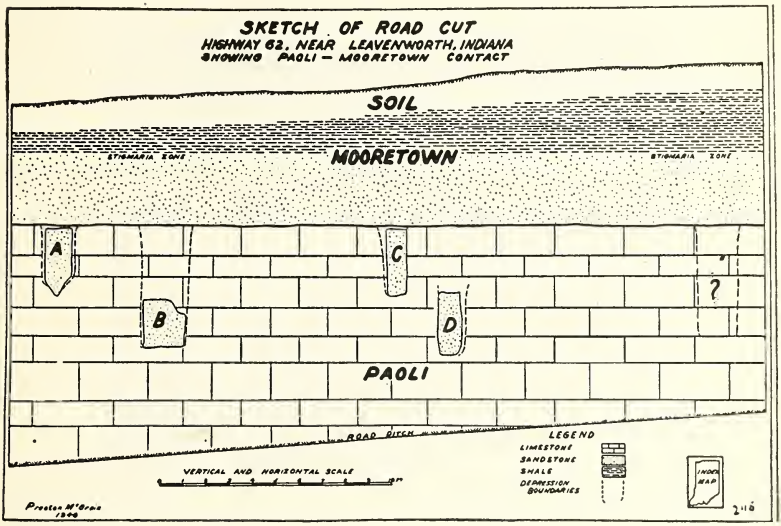


Fig. 1.

was but ten inches in diameter and projected three feet into the Paoli. Column D is also a remnant, its top portion having been removed by operations in making the road cut. This remnant is eleven to thirteen inches in diameter and it extends at least five and one-half feet into the Paoli. The actual base could not be determined. In general, structural features appear to be lacking in these columns. However, in Column C there were traces of lamination with the beds inclined toward the center of the depression.

To the writer's knowledge features such as the above have never been described in Indiana literature, and consequently their origin hasn't been discussed. Actually little is known about the upper surface of the Paoli limestone. As a rule the contact is seen only in quarries, road cuts, and vertical or nearly vertical cliffs. Consequently little more than a line is visible from which we must interpret the nature of the contact. Such is the case of the area in question.

Several questions arise as to the origin of the depressions in the Paoli limestone and the columnar shafts of sandstone filling them. Did

the solution developing the pits take place at, beneath, or above a former water table? Did the solution take place before or after the deposition of the Mooretown? Although the depressions are cylindrical for the most of their length they are funnel shaped at the top, and Column A is tapering at the base. These facts, together with the fact that the surface between the major depressions exhibits negligible relief, strongly suggests that their origin and orientation were governed by water whose movement was controlled by gravity, thus being formed by solution above the water table. The Paoli is a relatively pure limestone and would tend to be dissolved by carbon dioxide charged waters with little difficulty.

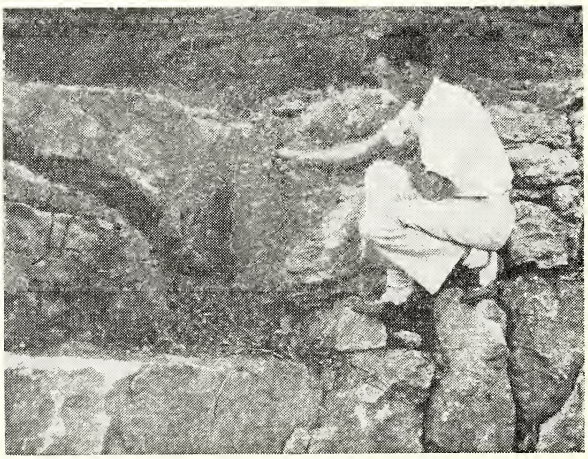


Fig. 2. View of the top of the Paoli limestone and one of the sandstone columns. Photo by P. D. Griffith.

The beds of the Mooretown appear to be flat lying or nearly flat lying, the only apparent inclination being the normal regional dip. There is no evidence of collapse or other disturbed features present in the unbedded Mooretown sandstone overlying the Paoli, such as would normally be present if the solution took place after the deposition of the sand. Also the *Stigmaria* zone has maintained its position consistently over the full length of the outcrop. In view of the above observations, it is the opinion of the writer that the depressions which served as moulds for the sandstone columns were caused by the solution of the Paoli limestone before Mooretown time, and that the Mooretown sands were deposited on this erosion surface thus forming the rather peculiar uncomformable relationship of the penetrating columns of Mooretown sandstone in the Paoli limestone.

Climatic Changes in Indiana

Stephen S. Visher, Indiana University

Changes of climate have occurred repeatedly here in the long past, and presumably will occur in the future. The following discussion is partly an abstract of the chapter on climatic changes in "Climate of Indiana,"[1] where more details are presented, with several additional graphs. Here, however, some new material is presented.

Several sorts of climatic changes certainly have occurred in Indiana: (1) At certain times in the remote geologic past, this area had a warm climate, as shown by the presence of many corals; at other times it was cold, as evidenced by the presence of a continental ice sheet deposit covering most of the State. (2) At times this area has been arid enough to permit the accumulation of widespread salt beds. At present it has a humid climate. The rock formations laid down under the sea, and also those accumulated in vast, almost-sea-level swamps, especially during the time of coal accumulation, are indications that at times in the past, surface moisture was even more abundant than at present. (3) At present, Indiana is not a windy state. The presence of extensive deposits of loess along the southwestern margin of the State and of extensive former sand dune areas in the northwestern eighth of the State suggest, however, that at some other times, the wind has been a more active agency than it is at present. (4) The alternation of glacial and interglacial epochs during the Pleistocene, one of the outstanding and especially puzzling aspects of the changes of climate, occurred in Indiana, where evidences of three glacial advances have been found, with two interglacial epochs. (5) Since the melting away of the late Wisconsin Ice Sheet, which disappeared from northern Indiana some 20,000 years ago, there have been a number of significant climatic oscillations. Studies of the pollen and other plant remains of Indiana peat bogs have shown that the vegetation varied from century to century, and that a milder, drier period preceded the present one.[2] There is some good evidence that this major mild drier period ended about 4,000 years ago, and that the modern period of increasing dryness and mildness commenced about a century ago.[3]

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[1] Visher, Climate of Indiana, Indiana University Science Series, 511 pp., Bloomington, Ind., 1944.

[2] Potzger, J. E., and Friesner, R. C.: Plant Migration in Indiana. *American Midland Naturalist.* 22:351-368, 1939, and several earlier studies of Indiana bogs by these men or their students; also papers by Markle and Welch, in *Proc. Ind. Acad. Sci.*, Vols 25 to 45.

[3] Matthes, F. E.: On the fluctuations of existing mountain glaciers and salt lakes. *Trans. American Geophys. Union*, 1939, pp. 518-522. (In his chapter on Glaciers in Meinzer (ed.): *Hydrology*, New York, 1942, Matthes concludes that

SOME EARLY WEATHER RECORDS NEAR INDIANA

The U. S. Weather Bureau was established in 1871; there are comparatively few Indiana records of rainfall and temperature prior to that date. Scattered records in and near Indiana during the half-century before 1871 indicate, however, that some years were exceptionally wet, that others were relatively dry, while others were unusually cold or warm.

Dayton, Ohio, only a few miles from Indiana's border, had its rainiest year of record in 1846, when 62.96 inches was recorded. Cincinnati received 65.18 inches in 1847. St. Louis, Missouri, received 65.36 inches in 1848. The rainfall of southwestern Ohio and southern Indiana was exceptionally copious during 1846 to 1860. Indiana rainfall records for 1858 are available for New Harmony, 48.7 inches (the maximum on record, except 1880), and for Richmond, 56.7 (exceeded only by 1855—56.8 inches). These totals are about 40 per cent more than Richmond's average. No Indiana rainfall records for 1846-1848 are now available.

Four curves by Hoyt of the variation in precipitation, 1880-1935, as shown by ten-year progressive averages for a region somewhat larger than Indiana centering in northeastern Indiana show that for the year as a whole, the fluctuation was sharply downward from 1880 until about 1901 when, on the average, the curve rose till 1930. For the months December to April, the rise which commenced about 1902 ended about 1912, since which period there has been a moderate decline. For the months May to August, inclusive, there has been a decline since about 1900. For the autumn months, however, there was an irregular rise from about 1910 to the end of this record, 1935.

At Chicago the coldest 20 year period of 1871-1940 was 1885-1904; the warmest was 1920-1939; the coldest individual year was 1875, the warmest was 1933. At St. Louis from 1845-1945, the coldest period centered at 1875, the warmest at 1939. For the United States as a whole, as well as for parts of the country, the years 1940-1946 have been less warm, and less dry than those of the 1930's.[4]

SOME INDIANA TRENDS

Precipitation. The curves for stations near Indiana or for large regions including Indiana lead to the expectation that the precipitation fluctuation in Indiana has been considerable. Bar graphs of the annual total rainfall at Indianapolis for 1871-1940 and of the rainfall of April to August, inclusive, at Indianapolis, 1883-1940, display a moderate but irregular fluctuation, without any clear evidence of trends. However when an analysis of the data is made by more refined methods, some evidence of trends appear. Figure 1, by Kincer, shows the fluctuations in Indiana's precipitation, 1875-1936, by the method of five-year moving

from about 4,000 years ago until about 1850 there was a colder, wetter period, during which many mountain glaciers accumulated. Since 1850 glaciers have been declining, rapidly since 1920.)

[4] Kincer, J. B.: Our Changing Climate. *Trans Am. Geophys. Union,* Vol. 27:342-47, June, 1946.

averages of the annual totals. This graph shows that the five years ending in 1929, 1908, 1892, and 1883 were especially wet while the five years ending in 1903 was only moderately less dry than the period 1930-40.

The precipitation departures in Indiana for each of the months were studied by the late Larry Page who found that for the average of 1916-1935, February and July were much drier than for the average of 1896-1915, but that April and September had much more rainfall. The other months had averages for the latter twenty years which were close to those for the first 20.

Temperature. Although the fluctuations in precipitation are more significant in Indiana than those of the monthly or annual average temperatures, because they are more critical and larger, there is especial popular interest in temperature changes. Between 1887 and 1940 the first 30 years displayed less extreme departures from the normal than is true

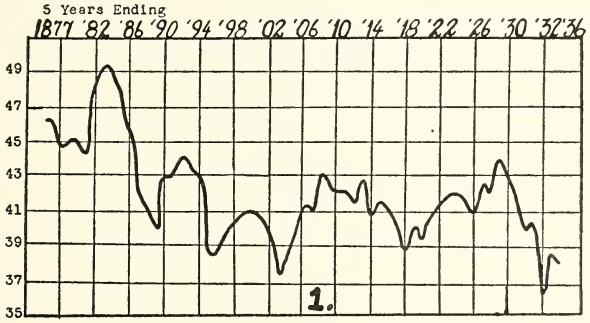

Fig. 1. Fluctuation in Indiana's average annual precipitation by five-year moving averages. (after Kincer.)

for the years 1917-1940. During 1887-1916 no clear trend is evident. From 1916 to 1940, however, a considerable upward trend occurred.

Figure 2 shows that the chief changes in temperature between the average for two halves of the 40-year period, 1896-1935, was that February became much warmer and May became considerably colder. The other months changed but little.

Figure 3, two interesting original graphs, show the variation in the mean winter and summer temperatures at Indianapolis from 1871 to 1940 averaged by five-ten- and 20-year periods. The 20-year curve for the summer months shows a slight decline until 1920 and then a rise. The 20-year curve of average winter temperatures shows a slight decline to about 1900 and then a rise. The ten-year average curves for the winter show only slight fluctuation until about 1915, but a distinct rise since then. For the summer, the ten-year average curve shows a much greater variation, with a sharper drop in the early years (to 1885) and a sharper rise, 1925 to 1940. The curves for five-year average temperatures show several curious alternations of rise and fall. Although since about 1917 the summer and winter curves have risen and fallen together, as they did also

for the second five years of the period 1871-1940, in a number of other five-year periods, they were in opposition instead of parallel.

Hence when the year as a whole is averaged, or summer or winter, the fluctuation from year to year in average Indiana temperature is rather irregular. Annual and seasonal averages are not, however, the

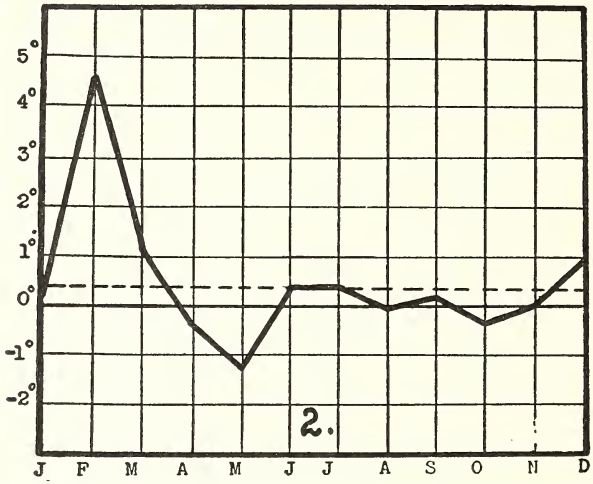

Fig. 2. Differences in average monthly temperatures, 1896-1915 as compared with 1916-1935. (after L. Page.)

temperature conditions that are readily evident; instead, the extremes are impressive. Three brief spells were exceptionally cold during the first 20 years of Weather Bureau record (1871-1890), but most of the records for lowest temperatures were established in 1917-1918, with a few others set in 1936. The duration of subzero weather in 1940 was also notable.

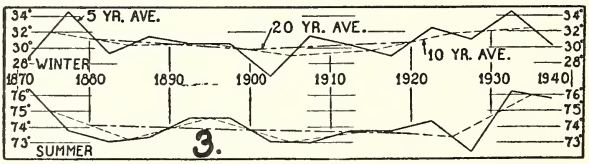

Fig. 3. Variation in the mean winter and summer temperatures at Indianapolis 1871-1940, averaged by five, ten, and twenty-five-year periods.

On the other hand, the data on high temperatures shows that most high temperatures records were established in the 1930's. Between February 19, 1936 and January 2, 1940, for example, no official temperature of zero was recorded at Indianapolis. Never before since the Weather Bureau station was established in 1871 have three consecutive winters passed without a zero temperature at Indianapolis. The nearest approach to three consecutive winters with no zero was, however, in 1889-1892, which had only two zero days in three years.

The annual number of days with temperatures of 90° or higher at Indianapolis has varied greatly from year to year. In 1877 no day was that warm, but in 1936 there were 53 such days. The annual average number of such days is 17. During 1871-1890, however, there were an average of 13; the next 12 years had an average of twice as many (26); the next eight years averaged 12; and the next nine years again averaged twice as many (24). The decade, 1921-1930, averaged 17, and the next nine years, 30. Thus there has been a curious alternation of groups of years, the hot ones in this special respect having about twice as many days with 90° or higher as occurred in the cooler groups. The groups of years are, however, not of equal length and within each group there are one or more years which departed widely from the average for the group. Hence the predictive value of this sequence is not at all high as applied to a single future year. An average increase is shown despite the fact that several early years were warmer than most recent ones and several years of 1900-1929 were cooler than most of the early years.

SUMMARY

During the long geologic past, Indiana has experienced several great changes of climate; numerous fossil corals indicate that it has been almost tropically warm; at another time it was almost covered for many thousands of years by a great ice sheet; it has been so dry that extensive salt beds accumulated; it has been covered repeatedly by the sea and once by great marshes in which our valuable coal beds accumulated. These great changes of climate occurred gradually, requiring thousands or millions of years.

Since white people came to Indiana, there has been continued fluctuation in temperature and rainfall. Many people believe that Indiana is becoming warmer and dried. But when the records are carefully studied, it is seen that while some early years were colder and wetter than most recent ones, others were exceptionally warm and dry. Indeed almost all recent records have been matched or closely approached years ago and vice versa. However 1930-1936 were relatively warm years on the average, although the winters of 1936 and 1940 were exceptionally cold. Some early years were much wetter than 1930-1936, but the driest summer of record in central Indiana was that of 1895 and the wettiest one was that of 1929. As to snowfall, the whole of southern Indiana had an average fall of 41 inches in 1917 but less than 2 inches in 1919.

In brief, while Indiana experiences sharp changes in temperature, rainfall, and snowfall, these changes are mostly irregular changes of weather. The changes of the average conditions which are called climate are slight during the lifetime of a person. The tendency to remember the highly exceptional conditions that occurred long ago, and to forget the conditions which prevailed most of the time, makes reliance upon memory far less dependable than reliance upon careful records. There is no good evidence that Indiana is becoming systematically, regularly, drier or warmer. Instead, there are irregular oscillations; for example the years since 1936 have been notably less warm and less dry than those of 1930-1936.

The Calumet Region in Model-Map Contour

ALFRED H. MEYER[1], Valparaiso University

A basal prerequisite to modern community planning and other studies dealing with the interrelation of human and physical geographic factors of a region is a clear picture of what the terrain looks like.

Such a land surface perspective is made available herewith for the Calumet region of northwest Indiana and adjacent northeast Illinois in the form of a contour model-map (Fig. 1).

The original contour model is 120 inches long and 45 linches wide, representing a distance of some 46 miles in length from east to west and 17 miles from north to south. Thus the horizontal scale of the model is about two and one-half inches to the mile.

Constructed from eight topographic quadrangles based upon two different horizontal and two different vertical scales, with modifications of certain topographic details as derived from other more recent maps and field observations, this contour model affords a unified one-scale view of the head-of-Lake Michigan area.

In photographic form as presented herewith, the contour model-map may be used as a base on which to superimpose regional geographical data, both human and physical. Such use is contemplated in further studies of the Calumet.

Structural Data

The model is constructed on a scale of 1:24,000, with a contour interval of 10 feet. It is based upon eight topographic quadrangles of the U. S. Geological Survey, a county map, a Great Lakes survey map, and local field observations. The topographic quadrangles are outlined and labeled on the index map (Fig. 2), which will help serve to identify the landsurface forms referred to in this paper and shown on the model-map.

Six of the "top" sheets—Palos Park (1925), Tinley Park (1926), Blue Island (1927), Harvey (1926), Calumet Lake (1927), and Calumet City (1926)—have a scale of 1:24,000 with a contour interval of five

[1] The present study is the second of a series of chorographic investigations of the Calumet area for which the author was awarded research grants by the Indiana and Michigan academies of science.

The first study, "Toponomy in Sequent Occupance Geography, Calumet Region, Indiana-Illinois", was published in the Proceedings of the Indiana Academy of Science, Vol. 54 (1945), pp. 142-158.

Since its publication another grant has been made to our regional research program by Mr. and Mrs. Carl J. Thrun in memory of their son, Cadet Donald M. Thrun, who was a victim of an aeroplane accident in the Second World War. This supplementary contribution is thus also gratefully acknowledged.

feet. The Tolleston (1897) and Porter (1934) scales are 1:62,500, with a contour interval of 10 feet.

The varying dates of survey, indicated above in parentheses, and the map scales for the different areas (both horizontal and vertical), should be noted as significant, inasmuch as they serve as a partial index to the relative degree of accuracy of the several sections of the model unit. It should be noted especially that the Tolleston quadrangle was surveyed as far back as 1897. Not only have drainage lines and lake shoreline features been considerably modified since that time, chiefly artificially, but landsurface forms have likewise locally undergone marked transformation.

To check on the more significant changes in this area the author has resorted to the use of the following maps: Map of Lake County, Indiana, 1943, by Wm. J. Schroeter (County Surveyor and Engineer), scale 1:84,480; Map of Calumet and Indiana Harbors, 1942, scale 1:15,000, Corps of Engineers, U. S. Department of War.

The latter map has also been used in revising the outlines of lakes of the Calumet quadrangle-Calumet Lake, Wolf Lake, and Lake George.[2]

As indicated above, local observations also have revealed some significant changes in landforms in the Tolleston area. These are primarily related to dunal features in the northeast corner of the quadrangle and to the ancient "fossil" historic beaches of old Lake Chicago—the Glenwood beach, the Calumet beach, and the Tolleston beach. Unfortunately a ten-foot instead of a five-foot contour interval was used for surveying this flattish area. Local observation leads one firmly to believe that contour lines were drawn only in a very generalized way without regard to detailed dunal configuration. The author, therefore, has taken the liberty, in a few well examined localities, to supply miniature "dunal" outlines so as better to suggest relief reality.

The old Tolleston map, moreover, shows several "island" configurations with as many as three or four contours (30-40 feet) where now are flat building sites of modern Gary.[3] Here also the contour configuration has been modified better to fit the relief perspective as it now appears to the eye.[4]

The Problem of Vertical Scale

The Calumet area roughly corresponds topographically to the Chicago Lake plain at the head of Lake Michigan and the adjacent part of the Valparaiso moraine bordering it on the south. Since most of the area

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[2] The outlines of these lakes have changed considerably in recent years and are subject to still further changes as the result of drainage and fill-in land reclamation projects.

[3] Gary was not founded until nine years after the Tolleston quadrangle was surveyed, and so the name does not even appear on the map.

[4] Air photographs of the area were not accessible during the war. Several Calumet landscape prints examined since then do not seem sharp enough to recognize fine relief details. Moreover, old shoreline beaches and dunes are commonly covered with a scrub-oak timber which further conceals ridges and dunal outlines.

Fig. 1. Contour model-map of the land surface and hydrographic features of the Calumet Indiana-Illinois region. Contour interval 10 feet.; ratio of vertical to horizontal scale 10:1. For horizontal scale and geographic identification see index map, Fig. 2.

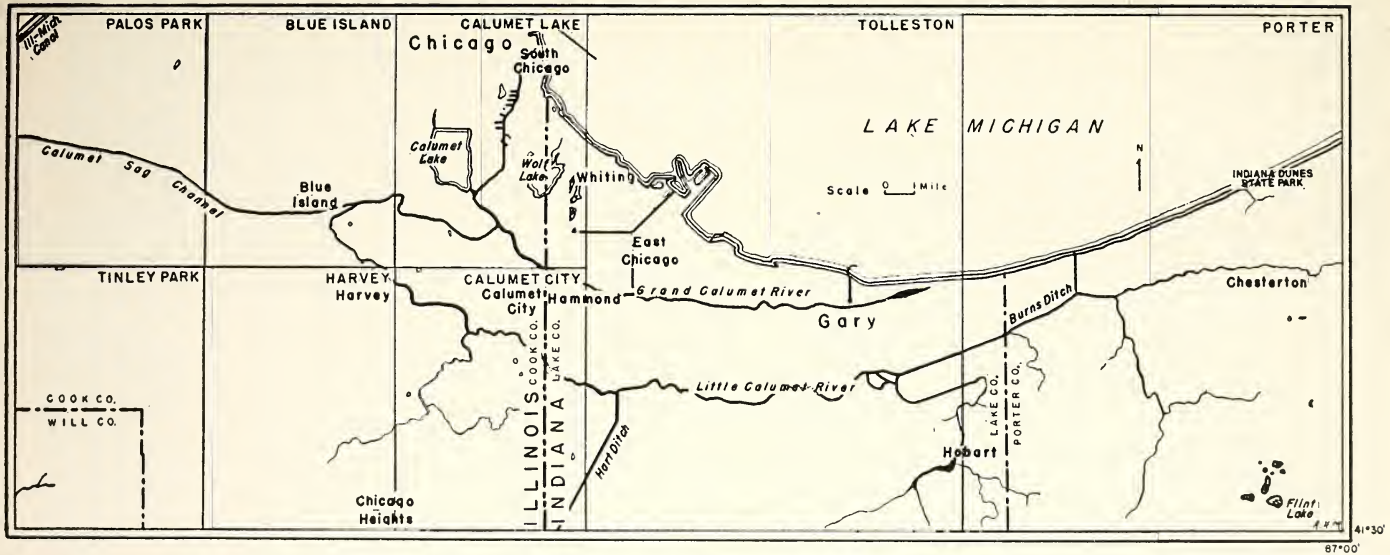

Fig. 2. Physical-political index map identifying the model-map features shown in figure 1. The eight topographic quadrangles which furnished the contour data for the model are identified by the rectangular areas labeled in each case in the upper right hand corner.

is thus low lying and very flattish, simple map contours alone do not seem as effective as "shadow-cast" contours in emphasizing such interesting features as the beach-dune ridges with which is associated geologically old Lake Chicago and with which are associated geographically the east-west arterial highways and shoestring settlements of the region.

While the typical relief model simulates well the terrain configuration, a contourless model likewise does not bring out the subdued landforms as well as does the model where the contours show and thus add to the effect of "sharpness" to such forms. Especially is this true in a photographic reproduction of a model landscape.

But whatever means are used to give a view of the lay of the land of a region, the third dimensional model perspective does introduce a vertical scale problem in such an area like the Calumet where a mountain-like dunal terrain configuration and a relative reliefless plains area lie side by side. Without exaggeration of the vertical scale, the Chicago Lake plain features would be almost indistinguishable. It was found by experiment that a ratio for a vertical scale to horizontal scale of 10:1 was necessary to bring out these subdued but very significant landscape features. On the other hand, such exaggeration of scale does undesirably accentuate the steepness of the slopes of the lofty Lake Michigan dunes. To offset a part of this distortion the dunes area of the model was given several extra heavy applications of white paint used to finish off the model to make it "photogenic".[5]

The Physiognomy of the Calumet Area as Revealed by the Model-Map

Three striking morphological units compose the Calumet scene—the flat Chicago Lake plain, the rolling Valpariso moraine, and the hilly Lake Michigan dunes.

The level of Lake Michigan varies as do the levels of the other great lakes, but is normally given as 581 feet above the mean tide level of the New York harbor. The Lake Michigan shoreline as outlined on topographic maps and as shown on our model-map practically coincides with the 580-foot contour. It will be noted then that from Chicago to almost as far east as Gary not a single contour is added except for a small island (Stony Island) and a few spoils dumps (see Calumet Lake quadrangle). Not until we reach the eastern end of the Tolleston region and otherwise south of the Grand Calumet River have the elevations risen sufficiently to call for an additional contour or two. And not until we reach the southern limits of the plain where it is bounded by the edge of a terminal moraine (the Valparaiso moraine) have the elevations risen sufficiently to call for six contours above the Lake Michigan contour, or an elevation of some 640 feet.

[5] Though the logarithmic principle of progressively using thinner and still thinner cardboard layers for the same contour interval from the lowest to the highest elevations would result in better slope perspective, this practice did not recommend itself here, since it seemed desirable above all to maintain correct comparative elevations for the beach-dunes of modern Lake Michigan and the three beach-dune ridges of ancestral Lake Chicago.

From here on the elevations rise more rapidly as we ascend the morainic ridge—in the northwest (Palos Park) to a maximum of 745 feet; in the southwest (Tinkley Park) to a maximum of 755 feet. From here on eastward the moraine extends south off the model-map but reappears in the southeast (Porter) where the crest occurs just northeast of the Flint Lake area and attains an elevation of 850-860 feet. From here north drainage is towards the Gulf of St. Lawrence via the Calumet rivers and the Great Lakes; from the ridge southward the drainage is typically to the Gulf of Mexico via the Kankakee, Illinois, and Mississippi rivers. The watershed thus becomes a sort of "continental divide".

The terrain of the Valparaiso moraine is typical of the youthful swell and swail topography of terminal moraines, with one conspicuous exception—the east central part of the Tinley Park quadrangle where, in an area of some half dozen square miles, drainage ditches had to be constructed in the flattish area to get rid of excess moisture.

Most of the morainic country is well suited to general farming, but locally steep slopes produce gullying when cultivation is attempted.

The Lake Michigan dunes, extending eastward from Gary, commonly attain heights of a hundred feet, the maximum heights being reached in the Indiana Dunes State Park where Mt. Tom attains the elevation of 773 feet, or a height of 192 feet above the lake.

This type of terrain with its fine sandy beach at the base affords a unique attraction for the resorter, the recreationist, and the tourist alike, having countrywide appeal.

The Calumet Plain in Retrospect and Prospect

In the early days marshes occupied much of this low-lying terrain (example, the famous Cady Marsh, the southwestern part of the Tolleston quadrangle, Hart Ditch area). These areas, often covered by several feet of water, proved a decided handicap to transportation and settlement. Even now, adequate drainage and sewerage disposal locally are concomitant problems associated with the two sluggish Calumet rivers and the low marshy areas in the Calumet Lake—Wolf Lake district.

The Grand Calumet River and the Little Calumet River form a sort of hairpin course, the latter flowing westward and the former originally flowing eastward emptying into Lake Michigan at the eastern extremity of the Tolleston quadrangle. Modern canalization of an earlier poorly defined drainage line of the Grand Calumet towards South Chicago and another westward along the "Sag", as well as the construction of the Indiana Harbor Canal at East Chicago, have modified the flow of the current. So low is the gradient of the Grand Calumet, however, that an east or west wind may well determine which way the stream flows.

A somewhat discriminating look at the model-map watershed between the Grand Calumet and Little Calumet rivers reveals the existence of a fine textured terrain configuration of some two contours above the level of Lake Michigan. This is called the Tolleston beach, the innermost one of the set of beaches of old Lake Chicago, the postulated ancestral lake of present Lake Michigan.

About a mile south of the Little Calumet and running parallel with it is another such ridge, the Calumet beach, noted on the model-map as generally a two-contour ridge some twenty feet higher than the Tolleston (620).

Still farther south, bordering the moraine, there occurs a third ridge, the Glenwood beach, rising from one to two contours above the Calumet beach, or an elevation of about 55 or 60 feet above the present Lake Michigan level. Since this beach-dune ridge in most places flanks the moraine, it is not readily distinguishable everywhere on even a five-foot contour interval map. In the southern part of the Calumet City quadrangle, however, this formation is distinctly discernible, particularly where it is extended across a former lake embayment in the form of a compound recurved spit (see the southeast part of the quadrangle).

It was these beach-dune ridges which made possible east-west travel across the Calumet marshes in the early days and which to this day, because of their elevation and sandy base, favor modern highway construction and traffic along their courses.

The only other conspicuous relief features which break the monotony of the lake plain are several elevated so-called "islands" which protrude above the early Lake Chicago waters, as, for example, Blue Island (Blue Island) and Stony Island (Calumet Lake).

If planeness of terrain combined with proximity to navigable waterways and with a strategic lake position for railway convergence upon a city is an asset favoring the growth of a metropolitan community, then the Chicago locale represents a unique topographic situation.

Entering the north limits of our model-map area at Eightieth Street, Chicago has already extended itself far south in the Blue Island and Calumet Lake quadrangle areas. In fact, the whole suburban area, including the cities of South Chicago on the north, Blue Island and Harvey on the southwest, Calumet City and Hammond on the south, and Whiting, East Chicago, and Gary to the east, now constitutes practically one large con-urbanized community with corporate boundaries in most cases even now hardly distinguishable geographically.

It is not, therefore, fantastic to envision metropolitan Chicago sometime sprawled out over practically the whole Calumet lake plain area. And by the possible future development of the Calumet harbors, rivers, lakes, and canals into a unified deep waterway system connecting the Gulf of St. Lawrence with the Gulf of Mexico, the Chicago-Calumet lake plain may yet become the site of the entrepot not only of the Western Hemisphere but of the entire world.

It will be obvious, therefore, that the presently promoted regional, county, and city planning programs in the Calumet region should take cognizance of these geographic facts. Not only will the satellite suburbs previously mentioned want to be alert to this situation, but even the "Calumet plain" communities still farther east, such as Hobart and Chesterton (see map), and the "Calumet moraine" communities farther south, such as Chicago Heights, Crown Point, and Valparaiso (the latter two cities just a few miles off the map to the south) want to observe

the relationship of the planning problem of their own communities to those of the Calumet region as a whole.

It is the hope, then, that the model-map photographed on a sufficiently large enough scale to bring out relief details, will prove helpful as a base map in planning such community projects.

Acknowledgments

In the construction of the Calumet model the writer has had the assistance of a number of his geography students—Dorothy Asch, Waldemir Beckman, Edna Bierlein, Loraine Bruening, Mildred Gieseking, Phyllis Graebner, Lois Hennig, and Lois Ihde. To all these students the writer is gratefully indebted for their painstaking care and skill in tracing, cutting out, and assembling the contour sections, basic to this type of landform study.

The Effect of World War II on Geography in the Secondary Schools of Indiana

EDWARD J. EAMES, Indiana State Teachers College

It is a recognized fact that geography has been seriously neglected in our schools. This fact has resulted in a serious lack of geographical knowledge which was quite evident prior to World War II and was brought out quite vividly during the war.

The results of a study to determine the effects of the war on geography in the schools of Indiana, made in preparing a master's thesis, are herein presented.[1]

Data for the study were obtained from the Annual School Report Forms 35-B on file in the state superintendent's office. Data were first gathered for the year 1945-46 then for the year 1940-41.

Of the ninety-two counties in the state seventy-six offered geography in 1945-46, compared to fifty-eight in 1940-41.

In 1945-46 two hundred forty-seven schools offered geography while only one hundred eleven schools offered it in 1940-41.

The number of courses offered increased from one hundred nineteen in 1940-41 to 281 in 1945-46.

The size of schools offering geography ranged from fifty-five to 5,070 pupils.

The mean number of schools per county offering geography increased from 1.91 in 1940-41 to 3.28 in 1945-46.

Geography in the Schools

It was found that a total of seventeen different courses were being offered in the schools in 1945-46, while only seven courses were offered in 1940-41. Of the ten courses added during the war, three were new versions of geography. These were: war geography, global geography, and air-age geography.

Commercial geography is losing some of its popularity, and physical geography is continuing its decline in the schools. Global geography is the most popular of the new courses.

There appears to be a definite tendency to depart from the traditional courses and to delve into the more unfamiliar and more exciting aspects of man's relationship to the world and its environment.

The frequency of schools offering more than one course increased as shown in Table I. In 1940-41 one hundred three schools, or 92.79 per cent, offered one course and eight schools, or 07.21 per cent, offered

[1] Edward J. Eames. *A Study of the Effects of World War II on the Position of Geography in the Curriculum of the Junior and Senior High Schools of Indiana.* Indiana State Teachers College (1946), No. 544.

two courses. In 1945-46 two hundred eighteen schools, or 88.26 per cent, offered one course; twenty-eight schools, or 11.34 per cent, offered two courses; and one school, or 00.41 per cent, offered seven courses.

TABLE I. Number of Geography courses offered per school.

	1940-41		1945-46	
Number of courses	Frequency	Per cent	Frequency	Per cent
1	103	92.79	218	88.26
2	8	07.21	28	11.34
7	—	— —	1	00.41
Total	111	100.00	247	100.00

TABLE II. High school curriculums requiring Geography 1945-46.

Curriculum	Frequency
All	7
Commercial*	17
General*†	6
Industrial arts†	1
Total	31

* One each in same school.
† One each in same school.

There was an increase in the number of schools offering geography in both the senior high school and in the junior high school.

The various curriculums requiring geography are shown in Table II. The commerical curriculum heads the list. In one school geography was required on the industrial arts curriculum.

Geography offered under the title "High School Geography" is most frequently offered. World geography increased considerably in popularity.

CONCLUSIONS

Most of the geography being taught in the schools is taught by socal-studies teachers, most of whom probably have little or no training or background in the field. Therefore, it has been taught from the social-studies aspect, and the true geographical view-point has been neglected.

The war has done much to aid the cause of geography. Now the responsibility for continuing this good work is with the colleges, the universities, and with educators in general.

RECOMMENDATIONS

Greater stress must be placed on the inclusion of geography in the curriculum of the schools of Indiana.

Certain specifications should be set up regarding the professional training standards for teachers teaching geography.

Anderson: Profile of An Industrial City

J. C. FINNEY, Anderson High School

Introduction.—The northeast quarter of the State of Indiana has a well-defined manufacturing region which extends from Indianapolis to Fort Wayne. In this district there has been an intrusion of important manufacturing interests into productive agricultural territory. In the cities of this region trade and distribution are still important activities. In the entire area the importance of farming is still evident. With the rise of the automobile industry the importance of industry increased rapidly; factory workers now outnumber farmers throughout the district. According to Harold H. McCarty the Indianapolis-Fort Wayne Manufacturing Belt accounts for about 1.2 per cent of the nation's manufacturing, or about one-third of the total for the state of Indiana. Of this output, about one-half comes from the city of Indianapolis. The remaining output is divided among the intermediate cities.[1]

Historical Development.—The advantages of the present site of the city was recognized many centuries ago. A site approximately four miles from the city was chosen by a group of pre-historic Mound Builders as the location for their village. Their settlement was located on the south bluffs overlooking the flood plains of White River. This location on high dry ground protected them from the ravages of floods, and at the same time, it furnished the settlement with an adequate water supply.

Next, the region was settled by a group of Indians, who established a settlement near the present city. This settlement was an important stopping point for Indians moving between Michigan and Kentucky. The importance of this trail has had its influence on the present city. State Highway No. 32 follows the route of this old trail between Anderson and Muncie.

Anderson is not the oldest city in the state, but it is an old city for central Indiana. It is known to have been in existence as an Indian village in 1812, for it was in 1813 that troops under the command of William Henry Harrison attacked and destroyed it. At that time, and later, the site of the city was occupied by the Delaware Indians. Their village was located on the south bank of White River, a navigable stream at that time, near where the Main Street and Traction bridges cross the river, and extended to the vicinity of Fifth and Main Streets. The city was named after the principal chief of this tribe, Kik-Tha-We-Nund, or in English, Anderson.

In 1837, by special act of the legislature, the county seat was moved from what is now Pendleton to Anderson-Town, which was a village of

[1] Harold H. McCarty, *The Geographic Basis of American Economic Life* (New York: Harper and Brothers, 1940), p. 324.

less than one hundred people, composed of pioneers, Indian traders, and adventurers.

The year 1837 also saw the completion of the Central Canal, a branch of the Wabash-Erie Canal which not only increased the population but also gave business an impulse which created the first boom. By 1839, the population had increased to 350.

In 1851, Anderson had its first major fire and the entire business section was destroyed. To rebuild the town a railroad was built from Indianapolis. This created another major boom and growth of population.

The first gas well was drilled on March 31, 1887, and when gas was struck, newspapers carried the news all over the country. The town of Anderson again became prominent, and the people from all over the country began to come to the city. The little town began to grow rapidly. Industries started moving into the city because of the abundance of cheap fuel. For several years, this was the principal factor for the influx of new industries. As time passed, however, and the supply of natural gas was exhausted in this territory, it was found that Anderson has many advantages essential to successful and profitable operation of many types of manufacturing.

Location.—Anderson (Lat. 40°2′; Long. 85°49′) is the county seat of Madison County. It is located in the central part of Indiana, thirty-eight miles northeast of Indianapolis, in one of the best corn and wheat belts of the United States.

It is near the centers of production, distribution, and population (near Linton, Indiana). The city's location puts it in advantageous position for the receipt of raw materials and for the distribution of the finished products. It is close to all the major markets of the Middle West.

Transportation Facilities.—The city is well located from the standpoint of railway and bus facilities. Four railways and seven bus lines provide excellent service to all parts of the state and nation.

The major bus lines are supplemented by numerous companies which operate to the factories in the city. During the war buses operated from all parts of central and eastern Indiana.

Twenty trucking companies maintain terminals in the city and provide over-night delivery service to all the larger markets within a radius of 300 miles.

Three State Highways, Nos. 32, 9, and 109 and fourteen paved roads lead into the city. State Highway No. 67, which once passed through the city, bypasses the city about one mile south of the city limits. This change was made at the request of city officials in an attempt to relieve traffic congestion. State Highway No. 9 will soon be removed for the same reason.

Fuel and Water Resources.—Even though the local supply of natural gas was exhausted long ago, the city's industries still secure natural gas at one of the state's lowest rates. Formerly the Central Indiana Gas Company, which serves the city, used artificial gas made from coke; however, a change was made to natural gas in 1944. The natural gas is brought in by the Panhandle Line from Texas. In case of a break in the

line or any other emergency, the company is prepared to produce an oil gas; this means that all consumers can depend upon interrupted service.

All of the industrial plants of the city are large consumers of natural gas. Most of the plants are served from the local lines; however, Delco Remy has its own direct outlet and is not served by the local distribution system. All industrial consumption of natural gas is handled through the company's Muncie office.

The Municipal Power Plant furnishes electric power to domestic and industrial consumers at a rate lower than in 80 per cent of the cities in Indiana. The source of this electric power is coal. Most of the coal used comes from West Virginia; the plant does not have the necessary pulverizers or chain-grate stokers to use Indiana coal. The average daily consumption of coal is 250 tons or over four carloads. This amount generates approximately 4,750,000 pounds of steam during the twenty-four hour period.

In addition to the amount of electricity produced in the Municipal Plant, the city uses a minimum of 435,000 kilowatts per month from the Indiana General Service Company. This amount must be used in order to maintain a substation in the city. In case of breakdown in the local system, the city can use all the additional power needed from this substation.

Electric power is directed to the industries, in all parts of the city, through four substations. These substations are so arranged that power is furnished to industry without fear of a long interrupted service. Whenever a breakdown occurs at one substation, power can immediately be cut in from one of the other substations. This is very important to all manufacturers.

All the major industries secure power from the city plant. In addition to the power furnished by the city, Delco Remy and Guide Lamp have direct connections with the Indiana General Service Company. Even with these connections, Delco Remy takes approximately 140,000 kilowatts and Guide Lamp approximately one hundred thousand kilowatts from the local plant.

Anderson has a Municipal Water Works, which furnishes the necessary water to industry and domestic consumers at a very low cost. Most of the water used in the city is derived from White River; however, one well is used in supplying the city. The city plant pumps approximately 2,500,000,000 gallons of water a year. The average daily consumption of water is 6,800,000 gallons. The maximum amount of water pumped during a twenty-four hour period was 9,000,000 gallons; the minimum was 4,500,000 gallons. Approximately 750,000 gallons of water are derived daily from a well located near the Madison Avenue bridge.

Many of the factories, such as Delco Remy, Guide Lamp, and Nicholson File Company, have their own wells to supplement the supply from the city. Delco Remy recently leased from the city a well which is used to operate the air conditioning system of one of its plants. Most of the factory wells, however, are declining in output; so that the city is preparing to furnish a greater supply of water to industry.

Population.—Anderson had, according to the Federal Census of 1940, a population of 41,472 inside the corporate boundaries of the city, with an estimated population of 45,000 in Greater Anderson. According to a recent Post Office survey, the present estimated population of Greater Anderson is 55,759.

The census figures show two decades in which the city's population increased approximately 10,000 people. The increase during the first period (1890-1900) was a result of the exploitation of the city's natural gas resources. The rapid development of the Delco Remy and Guide Lamp divisions of General Motors accounts for the second period (1920-1930) of growth.

The most rapid period of growth has occurred since the 1940 census. The Post Office estimate for 1944 shows a population increase of over 10,000 for Greater Anderson. A large part of this increase was absorbed by the city. This increase came as a result of increased industrial production during World War II.

The city's increased growth shows a slight change in the elements which make up its population. The Census of 1930 showed the population was composed of 95 per cent native whites, 3 per cent negroes, and 2 per cent foreign born. In contrast, the present Chamber of Commerce estimate lists the city as containing approximately 90 per cent native whites, 8 per cent negroes, and 2 per cent foreign born. The increase of 5 per cent in the negro population was probably due to the attraction offered by the industries of the city.

The city stands second to Muncie in population; however, Madison County is far ahead of any county between Marion County and Allen County. in population. The reason for this condition is that Anderson is not the only industrial city in the county. The cities of Elwood and Alexandria are manufacturing centers in their own right.

Industry.—Anderson boasts of 106 manufacturing enterprises producing 176 different articles which are shipped to all parts of the world. Two of the largest automobile accessory plants and the largest religious publishing plant in the world are located in the city.

In normal times, there are approximately 18,000-20,000 industrially employed, with a payroll of approximately three and one-half million dollars per month. The city has an annual industrial output of $60,000,000.00 or over $1,000 per inhabitant.[1]

The location of the city's industries offers an interesting study in urban geography. Like most industrial cities, in the belt of cyclonic disturbances, the major industrial development is in the southeast section of the city. A section fifteen blocks square in the extreme southeast section of the city contains nineteen industrial plants. These plants have excellent highway connections with State Highways Nos. 32, 109, and 67. In addition, railway switching facilities are available from all major lines entering the city. The location of the industries in this section of the city helps to eliminate the smoke problem, the prevailing westerly winds

[1] Otis W. Freeman, "Major Cities of Indiana," *Economic Geography*, XXI (April, 1945), pp. 122-124.

tend to keep the smoke and odors from the commercial and newer residential sections of the city.

Other sections of industrial development have been established in the west and northwest section of the city. These industries, with the exception of the Guide Lamp, are small industries, which cause no major smoke or dirt problem.

Urban Pattern.—The city in its street plan follows, for the most part, a rectangular pattern. The east-west streets are numbered from First Street on the north to Thirty-eighth Street on the south. The north-south streets are named, however, with no particular plan being followed in the naming. Meridian Street is the principal north-south street and is the starting point for the numbering of east-west streets. A few diagonal avenues keep the rectangular plan from being perfect.

The city's street pattern was established before the present extensive use of the automobile. However, since the removal of the street car lines, the streets are adequate for two way traffic. These facilities are taxed to capacity for a period of about one-half hour before the beginning of the morning shift and for another short period after work in the evening.

The urban profile of the city is characterized by smokestacks, which reflects the city's industrial activity. The city's low buildings suggest a close proximity to its rural surroundings. The tallest building in the city is the incompleted Tower Hotel Building. This building which is 12 stories high, was begun in the late 1920's; with the depression of the 1930's work was stopped because of lack of funds. The outer shell of this building is a silent reminder of one of the city's greatest periods of expansion.

Business Indicators.—The importance of Anderson as a wholesale and retail trading center is decreased by its close proximity to Indianapolis.

A study of such business indicators as first-class mail distribution, long-distance telephone calls, express shipments, and hotel registrations show that business and industrial activity in Anderson is dependent upon Indianapolis and the out-of-state cities of Chicago, Detroit, Cincinnati, Dayton, and Cleveland.

Summary.—The profile of Anderson shows the following outstanding features:

1. Although, historical incidents have been important in the growth of the city, geographical advantages have maintained the city's importance.
2. The growth of the city has been dependent upon the growth of industries.
3. The growth of industries, in turn, has been dependent upon the availability of raw materials.
4. The proximity of the city of Indianapolis decreases its importance as a wholesale and retail center.
5. The study of business indicators shows that Anderson is economically related to Indianapolis, Chicago, Detroit, Cleveland, Dayton, and Cincinnati.

HISTORY OF SCIENCE

Chairman: W. E. EDINGTON, DePauw University

Dr. C. A. Behrens, Purdue University, was elected chairman of the section for 1947.

ABSTRACTS

The First Five Years of the Indiana Academy of Science. WILL E. EDINGTON, DePauw University.—The Indiana Academy of Science was organized on December 29, 1885, following a call issued by the Brookville Society of Natural History some months previously. The Brookville Society was organized in 1881, and was one of a number of similar societies that had been organized in various towns in Indiana at different times in the 1870's and 1880's, had flourished for a time and had become inactive. Amos W. Butler was the principal founder of the Academy, but he had the enthusiastic backing of David Starr Jordan, the two Coulter brothers, Richard Owen, Ryland T. Brown, and others. The Proceedings of the Academy were first published in 1891, and the purpose of this report is to describe the work of the Academy preceding 1891. The report will eventually be published as a part of the Academy sponsored volume, "Indiana Men of Science," the material for which is now being compiled.

A Historical Sketch of the Purdue Biological Society

C. A. Behrens, Purdue University

The University's interest in the presentation of the development of Natural History and Scientific subjects to the more or less meagerly informed individual manifested itself at a rather early date.

In 1883, when such brilliant, adventurous, courageous and ingenious men as Ferdinand Cohn, Louis Pasteur, Robert Koch, Elie Metchnikoff, Lord Joseph Lister and Paul Ehrlich and many others were making monumental scientific history, some of the faculty and students organized a group known as the Purdue Scientific Society.* The first meeting was held in the Biological Laboratory of the Main Building, Professor Charles Reed Barnes was chairman. Subjects pertaining to the various branches in Agriculture, Engineering and Science were presented.

It is of interest to note that John M. Coulter, then of Wabash College, discussed "The Physical Basis of Life". Winthrop E. Stone, later the University's President, a recent graduate of the University of Goettingen, spoke on "American Students in German Universities". Meetings were held in various buildings, depending to some extent on the nature of the program and the facilities required for the speaker.

Most of Purdue's early scientific elite were members of its first scientific society. To mention only a few of whom we have heard and have read of their noteworthy attainments were John C. Arthur, Charles R. Barnes, Stanley Coulter, John V. Nef, William C. Latta, Henry A. Huston, James Troop, Katherine, Helen and Michael Golden, Frank L. Rainey, Henry L. Bolley, Anne M. Lutz, Arthur Goss, Handley Caraway, Ernest Knaufft, Erastus Test, Presidents James H. Smart and Winthrop E. Stone; John S. Wright, H. E. Stockbridge, Winthrop K. Howe, William P. Turner, and Pierre van Landeghem.

Arthur Goss served as the Society's first President, Handley Caraway Vice President, Frank L. Rainey Secretary and Treasurer and Charles Gough as Marshal.

Later Katherine Golden and John S. Wright held the office of President, Winthrop K. Howe and W. F. McBride Vice President, Henry L. Bolley, Herbert N. McCoy and John S. Wright Secretary-Treasurer and Enos L. Shaw was Marshal.

With the rapid development and formation of various scientific societies in Agriculture and Engineering the Society confined its subjects to Biology and Chemistry.

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* The author is greatly indebted to Dr. John S. Wright, Eli Lilly Company, Indianapolis for much of the information of the Purdue Scientific Society and to Dean Howard E. Enders, Purdue University, relative to the early developments of the Purdue Biological Society.

Purdue's pioneering Scientific Society, a forerunner of the Biological Society and which flourished some twenty years before the latter organization came into being, went the way most similar groups did.

The Purdue Biology Society* was conceived when Dean Stanley Coulter, Professor Howard Enders, and Drs. Oliver Terry and Severance Burrage, sole members of the Biology Department, in 1907 met in their homes, to discuss research that was being carried on in the various fields of Biology. After their scientific discussions lunch was served and since three of them were "chain smokers" one can imagine that the air was pretty blue.

In 1909 this very select group expanded and held their meetings in the old Science Hall. Some of you will recall that this building was formerly the old Engineering shops and stood on the present site of Stanley Coulter Hall.

At first there were no officers or dues. Stanley Coulter always presided, Professor Enders was responsible for the program and Professor George Hoffer was secretary. Meetings were held about twice a month and some twenty papers were presented during a school year. The lectures were very popular and the average attendance was around sixty.

General subjects were discussed from various angles as for example when heredity was taken up the different professors on the campus presented that subject as it was related to their particular field. Professor G. I. Christie spoke on Heredity in relation to crops, Professor A. L. Winako to grains, Professor W. W. Smith to animal husbandry, and Dean Stanley Coulter to plants. Professor H. E. Enders expounded on Heredity and the Mendelian ratio and Professor E. H. Davis discussed the famous Kallikak family.

One would assume that the idea back of this plan was excellent especially at that time, for it tied the various departments together. The professors interested more or less in some branch of the same field became not only better acquainted but were aware of what was going on in the various lines of the subject as a whole not to say anything about a more comprehensive consideration of Biology.

In 1913 it was decided to do away with these general presentations and to confine these gatherings to a sort of a round-table discusion—a seminar if you please—of subjects which were strictly research in nature. The meetings were attended mainly by members of the Biology staff. This change from a popular to a scientific approach of the subject matter at this time, apparently, sounded the death knell to the organization, for interest rapidly waned and by the end of the school year of 1914 the meetings were discontinued.

After a comparatively short lapse of time in 1921 the Purdue Biological Society was reorganized in the regular big business manner with a constitution and by-laws. The membership was open to everyone interested in any line of Biology. Yearly dues were one dollar, every cent of which was to go to bring in outside speakers. Its aims were:

"To present and discuss all kinds of biological problems.

To bring most prominent scientists of our various interests before us.

To provide a common avenue where all members of the University community interested in these lines may become better acquainted.

To keep members informed of all national and local meetings of a biological interest.

To promote study of migratory birds"—a chart of the same was maintained in Stanley Coulter Hall.

Meetings were held at least once a month, often times twice, and its officers were: C. A. Behrens—President; M. W. Gardner—Vice-president; I. L. Baldwin—Secretary-treasurer.

In turn the other officers of the society were: M. W. Gardner, J. J. Davis, L. E. Compton, I. L. Baldwin, L. F. Heimlich, C. L. Porter, B. N. Prentice, E. J. Kohl and D. H. Dunham—Presidents; L. F. Heimlich, F. D. Cullinan, L. P. Doyle, G. N. Hoffer, C. L. Porter, B. Pontius, C. O. Lee, Dorothy Thompson, H. G. DeKay—Vice-presidents; while I. L. Baldwin, G. N. Hoffer, L. E. Compton, B. N. Prentice, Dorothy M. Thompson, D. C. Cooper, J. H. Mac Gillivray and P. R. Miller held the office of Secretary-treasurer.

Papers given during the first year of the societies reorganization were of a diverse nature and were as follows: December 12, 1921, Dr. C. A. Behrens: Technique in Advanced Bacteriology with Practical Applications. January 9, 1922, Dr. E. B. Mains: Rust Resistance with Special Reference to the Leaf Rust of Wheat and Rye. January 30, Mr. J. B. Kendrick: The Colorimetric Method of Detecting Hydrogen Ion Changes Induced by Bacteria in Sugar Media. Mr. D. H. Thompson: Factors Controlling Facet Number in the Eye of Drosophila melanogaster. February 13, Professor J. J. Davis: Entomology and Its Relation to Man. March 13, Professor B. N. Prentice: Present Status of the White Pine Blister Rust. April 7, Professor W. F. Gidley: Blood Phenomena and Their Chemical Significance. October 30, Professor H. S. Jackson: Mushrooms and other Fungi in the Woods at the Present Time. November 3, Dr. Maynard M. Metcalf, Orchard Laboratory, Oberlin, Ohio: Animal Distribution. November 13, Dr. R. A. Whiting: Swine Dysentery. December 4, Mr. F. P. Cullinan: The Effects of Pruning and Soil Treatments Upon the Growth and Development of the Root System of Apple Trees; and December 11, 1922, Mr. C. M. Vestal: Mineral Supplements to Protein Feeding.

As time went on the society was addressed by such outstanding national and international figures as: E. F. Phillips—Chief of Division of Bee Culture, U.S. Department of Agriculture; C. R. Ball, Head of the Office of Cereal Investigations of the Bureau of Plant Industry; T. H. Frison, University of Illinois; F. D. Kern, Dean of Graduate School, Pennsylvania State College; Drs. H. J. Page and D. W. Cutler of the Rothamsted Experiment Station, England; C. A. Shull, Professor Plant Physiology, University of Chicago; P. V. Allison, Tropical Plant Research Foundation; H. H. Wetzel, Professor of Plant Pathology, Cornell University; A. H. Reginald Buller, Botanist, University of Manitoba; L. R. Jones, Head of Department of Plant Pathology, University of

Wisconsin; W. B. McDougall, University of Illinois; E. W. Lindstrom, Head of Department of Genetics, Iowa State College; C. R. Orton, Boyce Thompson Institute, Yonkers, New York; F. L. Stevens, Head of Department of Plant Pathology, University of Illinois; G. N. Hoffer, Pathologist, U. S. Department of Agriculture and Purdue Agricultural Experiment Station; H. B. Humphrey, Head of Cereal Rust Investigations of United States Department of Agriculture; F. E. Lloyd, MacDonald, Professor of Botany in McGill University, Montreal; F. W. Tanner, Head of Department of Bacteriology, University of Illinois; L. R. Tehon of the Illinois Natural History Survey; W. A. Jamieson, Director of Biological Division of Eli Lilly; M. H. Soule, Head of the Department of Bacteriology, University of Michigan; J. Henderson Smith, Rothamsted Experiment Station, England; and George Wagner, Zoology Department, University of Wisconsin.

Dr. R. B. Wetherill, a local physician and traveler of note, spoke to us on "Tropical Diseases" following his trip to Africa. Likewise Dr. Tetrault who had just returned from France told us about the famous Pasteur Institute. Also when A. G. Phillips at that time Head of the Poultry Department, returned from his trip to Europe he talked to us on "Innocence Abroad". For several years it was the custom to devote one meeting to a review of the most outstanding of the Bachelor's theses which were of interest to the Biological Society.

In some instances meetings were conducted jointly with the chapter of Sigma Xi, the Purdue section of the American Society of Plant Physiologists, and the Indiana Branch of the Society of American Bacteriologists, but for the most part independently. "Smokers", dinner meetings, dining at such familiar places as the Lahr House, Lafayette Club, and on the campus, were held.

The gatherings were not always of a serious turn of mind for two picnics were enjoyed; one in May 1925 at "Tecumseh Trail" and in 1927 "On the Wea". The announcement of the latter read something like this: "Meet at Coulter Hall. Proceed by Auto to the Wea where games will be provided for all. Big feed provided by the eats committee. Transportation furnished those without same. Come and bring the family." In short there was a great diversification in the program.

In 1928 interest in the Society had waned to such an extent that it too went the way of its predecessors. In 1942 the organization was resuscitated and up to date is carrying on in an admirable manner.

And so by four distinct steps the present Purdue Biological Society evolved.

The Early Development of the Fundamental Concepts of Plant Nutrition. (600 BC—1804 AD)

RAYMOND E. GIRTON, Purdue University

The nutrition of plants has long interested mankind as a fit subject for philosophical conjectures and for experimental investigation in more recent years. According to Julius von Sachs, the great German botanist of the 19th century, several questions have been presented for consideration. Briefly stated, they are: What is the nature of the food substances taken up by plants? In what way do these substances find their way into the plant? How are they distributed within the plant body? What is the nature of the forces employed?

The Early Greeks

As early as the 6th century before Christ, the Greek philosopher Thales, one of the Seven Sages, emphasized the importance of water in the nutrition of plants. According to him, water was the all important and essential food of plants. He supposed that plants derived all of their food and all of their substance from water alone. This early belief in water as the one essential food of plants was, strangely enough, echoed by van Helmont over 2,000 years later as the major conclusion of the first recorded experiment in plant physiology.

In the fourth century B.C., the renowned Greek teacher, Aristotle gave an entirely different answer to the question of what food substances are taken up by plants. Plants were compared to animals and the conclusion drawn that plants like animals could feed upon materials of like nature with themselves, but not upon materials of unlike nature. Hence the important food of plants consisted of the decaying animal and vegetable matter, the "humus" component of the soil. Since plants produce no excrement, as do animals, Aristotle believed that plants were able to select from the soil only those substances required for their structure. This food material was accordingly elaborated in the earth for the plants use, much as the food utilized by higher animals is elaborated in their stomachs. Therefore, the role of plants was considered to be passive in the work of nutrition, since the food which they absorbed was already prepared in the soil. Growth in plants was thus looked upon largely as a process of accretion, unaccompanied by chemical change.

The following rather cryptic statements of Aristotle serve to indicate some of his ideas upon this subject.

"Everything feeds on that of which it consists, and everything feeds on more than one thing; whatever appears to feed on only one thing, as the plant on water, feeds on more than one thing, for earth

in the case of the plant is mixed with water, therefore the country people water plants with mixtures of things.

"As many savours as there are the rinds of fruits, so many it is plain prevail also in the earth. Therefore also many of the old philosophers said that the water is of as many kinds as the ground through which it runs."

The Sixteenth Century

Leaving Aristotle, a long leap over some 19 centuries brings us to the great French potter Palissy (Bernard Palissy—1509-89 A.D.) who was also concerned with the question of plant foods. He observed that the growth of crop plants was markedly increased when manures and the ash of plants were applied to the soil on which crops were growing. Let us give this observation of Palissy in his own words rendered into English. "You will admit that when you bring dung into a field, it is to return to the soil something that has been taken away. . . . When a plant is burned, it is reduced to a salty ash called alcaly by apothecaries and philosophers. . . . Every sort of plant without exception contains some kind of salt. Have you not seen certain laborers when sowing a field with wheat for the second year in succession, burn the unused straw which had been taken from the field? In the ashes will be found the salt that the straw took out of the soil; if this is put back, the soil is improved. Being burnt on the ground, it serves as a manure because it returns to the soil those substances that had been taken away."

In considering the uptake of nutritive materials by plants, Andrea Cesalpino, a contemporary of Palissy, invoked the physics of his day for an explanation of how plants remove liquids from the soil. He stated that it was not the "ratio similitudinis, that is, the force which draws iron to the magnet, which causes the attraction of the juice by the roots, because then the smaller would be drawn to the larger, or the juice from the plant would be drawn out by the moisture of the earth. Neither is the movement due to the "ratio vacui," for the plant is not filled with air but with juice even though the soil contains both air and liquid. Cesalpino suggests, however, that since many dry objects such as sponges, linen and powder absorb moisture because they have more in common with water than with air; it appears that the absorbing organs of plants must be of this nature. These organs he considered fibroid, like nerves, so that suction (biblia natura) conveys the moisture to the place of internal heat, in a fashion similar to the movement of oil in the wick of a lighted lantern. Cesalpino further suggested that the pith, with its surrounding cylinder of wood, was the seat of internal heat in plants, and likened it to the spinal cord of animals with its enclosing vertebral column.

The Seventeenth Century

While agreeing with Aristotle's view of the selective property of roots, Joachim Jung (German mathematician and naturalist) took a different stand regarding the question of plant excreta. Jung believed

plants like animals also have their excreta, which in the case of plants are exhaled through the leaves, flowers, and fruits. He included resins and other exuded liquids as plant excreta and stated that a large portion of plant juices escapes from the plant surfaces by imperceptible evaporation, as with the case of animals. Jung further opposed Aristotles views by regarding the plant not as passively absorbing elaborated food from the soil, but as assisting in its nourishment by chemical activity.

Leaving the purely observational method of plant study and speculation, we turn now to the experimental method as introduced by the Dutch alchemist van Helmont. Johann Baptist van Helmont (1577-1644) performed what is considered to be the first recorded experiment of plant physiology in an attempt to determine the true nature of the nutritive materials used by plants. This experiment may best be described in a translation of his own words. "I took an earthen vessel in which I put 200 pounds of soil dried in an oven, then I moistened with rain water and pressed hard into it a willow shoot weighing five pounds. After exactly five years the tree that had grown up weighed 169 pounds and about three ounces. But the vessel had never received anything but rain water or distilled water to moisten the soil when this was necessary, and it remained full of soil, which was still tightly packed, and, lest any dust from outside should get into the soil, it was covered with a sheet of iron coated with tin but perforated with many holes. I did not take the weight of the leaves that fell in the autumn. In the end I dried the soil once more and got the same 200 pounds that I started with, less about two ounces. Therefore the 169 pounds of wood, bark, and root rose from the water alone."

Here we are back again to the early view of Thales that water constitutes the sole material from which plants are built. It is evident that van Helmont regarded the 2 ounce discrepancy in his soil weights as "experimental error". Also, the fact that he overlooked the atmosphere as a source of nutritive substance is undoubtedly due to the ignorance of the day regarding the true nature of air.

In contrast to van Helmont's neglect of the essential nutrient materials which the soil is now known to provide, we have the efforts of the German chemist Glauber (1650) in searching for the substances in manures which are responsible for the increased growth of plants, as pointed out by Palissy a hundred years earlier. Glauber was successful in isolating salt-peter from soil on which cow manure had been lying. He also found that application of this chemical to the soil was followed by greatly increased plant growth. Since the salt-peter from the dunged soil came from the urine and feces of animals, it seemed evident that this salt must have been present in the plant materials which constituted the food of these animals. This work of Glauber is considered to be the first definite connection of chemical substances with the nutrition of plants.

Viewing the subject of plant nutrition from a different approach, let us note the concepts which the Italian physician and plant anatomist, Malpighi, held as the result of his studies. Malpighi considered that the fibrous elements of the wood serve as the organs of sap conduction

from the roots, and that the wood vessels, which he called tracheae after the tracheae of insects, act as air passages. He believed that air was taken in by the roots rather than by the leaves. He did consider the leaves, however, as the seat of the changes which the crude juices of the plant undergo to fit them for maintaining growth. This belief was based upon experimentation with cotyledons (seed leaves) of the gourd which he considered true leaves. He found that the plumule would not grow if the cotyledons were removed. From this he reasoned that the liquid absorbed from the soil by the roots and conducted up the stem by the wood fibers, must be first elaborated into food in the leaves before being fed to the growing shoot. If the leaves were removed, as was the case with the cotyledonous leaves, the plant failed to grow because it lacked elaborated food. In this point, Malpighi came very close to the truth, although we now recognize the cotyledons to be food-storage organs primarily.

A contemporary of Malpighi was Edme Mariotte, a French ecclesiastic interested in the scientific learning of his day. Mariotte presented his views concerning the chemistry of plant nutrition in a letter dated 1679. In this document he discussed 3 hypotheses concerning the "elements" or principles of plants.

In his first hypothesis, he stated that there exists in plants many immediate "principles" such as water, sulfur, oil, salt, nitre, etc., which are made up of 3 or 4 simpler principles united into one body, as for example, Nitre=phlegma (tasteless water), "spiritus", fixed salts, etc. These simpler principles also are compounds of differing parts. He considered the union of these constituents the result of a natural disposition to move together and to unite upon touching.

In his second hypothesis he suggested that the possible sources of the several principles contained in plants come from the earth. Lightning burns the small particles of the air which are then carried downward by rain into the earth and absorbed by plants. Dry distillation of plants produces water, acids and ammonia. An ash results from burning; this ash contains salts which differ from one another according as they are mixed with more or less ammoniacal spirits, or other unknown principles.

In this third hypothesis, Mariotee maintained that the salts, earths, oils, etc., yielded by different plants are always the same, and that the differences in plants are due entirely to the way in which these principles and their simpler parts are combined. He stated a problem designed to demonstrate that plants do not draw their elaborated substance directly from the earth, but produce it themselves by chemical processes. The problem is as follows: A pot containing 7 or 8 pounds of soil will grow any of 3,000 or 4,000 different kinds of plants from the principles contained in the soil when watered with rain water. If different elaborated foods were required from the soil for each kind of plant (as held by Aristotle), 500 pounds of soil would be required for the three or four thousand plants on the basis of a dram of fixed salt and 2 drams of earth per plant. Thus some 70 times the soil quantity actually required would seem to be needed if Aristotle's contention were true.

To John Woodward (1665-1728) we owe the inception of the method of water cultures in the study of the nutrition of plants. Woodward grew spearmint plants in rain water, Thames river water, sewage water from the Hyde Park conduit, and sewage water plus an addition of garden soil. After 77 days of growth the following results were obtained:

Rain water	17½ grains
Thames water	26 grains
Sewage water	139 grains
Sewage soil	284 grains

From this experiment Woodward drew the following conclusion: "Vegetables are not formed of water but of a certain peculiar terrestrial matter. It has been shown that there is a considerable quantity of this matter contained in rain, spring, and river water, that the greatest part of the fluid mass that ascends up into plants does not settle there but passes through their pores and exhales up into the atmosphere; that a great part of the terrestrial matter, mixed with water, passes up into the plant along with it, and that the plant is more or less augmented in proportion as the water contains a greater or less quantity of that matter; from all of which we may reasonably infer, that earth and not water is the matter that constitutes vegetables".

The Eighteenth Century

Stephen Hales, English clergyman and "father of Plant Physiology" contributed to the subject of nutrition in 1727 by emphasizing his belief that air cooperates in the construction of the plant body in the formation of its solid substance, and that neither water nor the materials derived from the soil alone supply the substance of what plants consist. He concluded from dry distillation experiments that plant substance is made of sulfur, volatile salts, water and earth, and that all of these principles are endowed with mutual power of attraction. The leaves were considered important in the nutrition of the plant, since they draw up substance from the earth. He further believed that they also remove excess water by evaporation, retaining its nutritious parts, in addition to absorbing salt, nitre, dew, and rain. In considering light, which he supposed to be a substance, he asks: "May not light, which makes its way into the outer surfaces of leaves, and flowers, contribute much to the refining of the substances of the plant?"

The work of Joseph Priestley, another English clergyman and scientist, greatly stimulated interest in the effect which plants may exert upon the surrounding air. Priestly found that plants could purify air in which animals had been kept so that it could again sustain animal life. He stated his findings in 1771 as follows: "Plants instead of affecting the air in the same manner with animal respiration, reverse the effects of breathing, and tend to keep the atmosphere pure and wholesome, when it is become obnoxious in consequence of animals, either living, or breathing, or dying and putrifying in it." After his discovery of oxygen in 1774, Priestley attempted to advance his work but was not able

to obtain consistent results with his experiments since in some cases purification of air was obtained, while in other cases the plants appeared to contaminate the air as did animals.

The difficulty encountered by Priestley was explained a few years later by the Dutch scientist, Ingenhousz who is said to be one of the most brilliant investigators of the 18th century. Ingenhousz in 1779 was able to show that it is only in light that plants are able to purify the air, since in darkness they contaminate the air in the same manner as animals. He also demonstrated that it was the aerial parts of plants—the leaves and stems—that were active in this respect, while flowers and fruits did not possess this power.

After the work of the French chemist Lavoisier had shown the nature of the gases of the air and explained the process of combustion, Ingenhousz expanded his ideas on the inner nature of the process. He stated in 1795 that all vegetables continually give out carbon dioxide but that green leaves and shoots only release oxygen in sunlight or clear daylight. Moreover he considered that the carbon dioxide of the air was the main if not the only source of carbon dioxide to plants. The following statement of Ingenhousz indicates his conclusion concerning this phenomenon; "plants changing in the dark more respirable air into carbonic acid than they can digest, they throw out a large quantity of it, and thus render the air in contact with them as respirable, and that in the day they absorb with the atmospheric air so much matter of heat and light, or caloric furnished by the sun, that they cannot all digest it and therefore throw it out as superfluous, combined with the oxygen, which has thus acquired the nature of vital air."

Early Nineteenth Century

In closing this discussion, there is yet one more worker who must not be neglected. Theodore De Saussure (1767-1845), a brilliant Swiss scientist, published work of extreme importance regarding the nutrition of plants. De Saussure demonstrated by careful quantitative studies of the gas exchange of plants that not only was carbon fixed in plants, but also the hydrogen and oxygen derived from water. This process he found was essential to the life of the plant. He was also able to demonstrate that there is no normal nutrition of plants without the utilization of nitrates and of mineral matter supplied in dilute solution by the soil. Even though the amount of mineral material required for the growth of plants was small, yet a certain amount of ash materials was essential for their growth.

Conclusion

In retrospect, let us briefly recall certain concepts in the evolution of our early knowledge of the nutrition of plants. First, the nature of the materials required by plants: Aristotle and his followers down through the centuries believed that plants require complex, elaborated foods. Second, Aristotle, Palissy, and Woodward emphasized the soil as the all important source of required materials. Third, Hales, Priestley,

and Ingenhousz called attention to the air as an important source of materials employed in the nutrition of plants. And fourth, the importance of water in the building of plant substance was emphasized beginning long ago with Thales, and many centuries later by van Helmont, and still later by the careful quantitative studies of De Saussure.

Chronology

640 - 546 BC	Thales	Plants are made of water.
384 - 322 BC	Aristotle	Elaborated food is taken from the soil.
1563 AD	Palissy	Soil salts occur in plants.
1583	Cesalpino	Physical explanation of absorption attempted.
1587, 1657	Jung	Active absorption of plants emphasized.
1577, 1644	van Helmont	All plant substance comes from water.
1650	Glauber	Salt peter promotes growth.
1671	Malpighi	Leaves are essential for growth.
1679	Mariotte	Plants synthesize their own foods.
1699	Woodward	Plants are formed from soil substances.
1727	Hales	Leaves use light and air in food synthesis.
1771	Priestley	Plants purify the atmosphere.
1779, 1796	Ingenhousz	Illuminated leaves absorb carbon dioxide and produce oxygen.
1804	De Saussure	Both carbon dioxide and water are fixed quantitatively in plants.

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MATHEMATICS

Chairman: HAROLD E. WOLFE, Indiana University

Dr. J. C. Polley, Wabash College was elected chairman of the section for 1947.

ABSTRACTS

The American University at Shrivenham Barracks. P. D. EDWARDS, Ball State Teachers College.—Shrivenham American University, although created for army personel awaiting redeployment, was a true American University operated on foreign soil. The faculty of more than 220 members represented 149 American institutions of higher education. About 150 were civilians who were sent to England for this purpose. The University was divided into eight sections which corresponded to the usual division of an American University into Schools. The faculty of the Mathematics Branch included fourteen civilians and seven members of the army all of whom were college teachers in civil life. The enrollment was approximately 4000 each term. Approximately three-fourths of the student body had had actual combat experience. A pure elective system prevailed, and under it the Mathematics Branch was exceeded in size only by one other branch. In spite of the unusual difficulties which prevailed very gratifying results were obtained.

The American University at Bairritz. J. C. POLLEY, Wabash College.—The American University at Bairritz, France, was operated from August 1945 until March 1946. The author discussed some of the difficulties encountered in establishing an American school in the midst of a French seaside city. Especial emphasis was given the program offered in Mathematics.

Application of the linear transformation. JOSEPH LASALLE, Notre Dame University.—Several applications of the linear transformation $(az+b)/(cz+d)$ to problems in electrical engineering were presented. A clear geometric picture of the variation of power transfer to a load with change of load or generator impedance and of the condition for maximum power transfer is obtained by means of the transformation $(1—z)/(1+z)$. The "circle" diagram which relates impedance to reflection coefficient can be used for this purpose. Though the concepts of reflection and transmission coefficients appear to be more natural than those of impedance and the resulting equivalent circuits, particularly for wave guides, only limited use of the former concepts have been made. This may be due to difficulties in applying the general linear transformation. Algebraic identities which simplify the application of this transformation are given.

The Force of Mortality Function. F. C. SMITH, Lincoln Life Insurance Co.—In this paper, the author discussed the definition of the Force of Mortality function, μ_x, and some of its properties. Several methods of approximating the values of this function are also presented. The importance of this function in the field of actuarial mathematics is stressed, and the effects of assuming the Gompertz and Makeham hypotheses are shown.

Recent progress in the theory of compressible fluids. RUFUS ISAACS, Notre Dame University.—Recent developments in areonautics, gas turbines, etc., make the need for a workable theory of compressible fluids imperative. In the past, progress has been checked, first, by the complexity of the theory and, second, by the formidable amount of numerical computation needed to apply what theory is extant. The new approach of Bergman to the methods of Chaplygin now yields a useable theory when used in conjunction with such modern computational devices as the Aiken machine at Harvard University.

In two-dimensional incompressible flows, the stream function satisfies the Laplace equation. Thus each flow pattern can be determined from an analytic function of a complex variable by taking the imaginary part. In distinction, for compressible fluids the differential equation satisfied by the stream function is non-linear. But Chaplygin showed that in the hodograph plane where the velocity components are the independent variables the equation becomes linear, although complicated. Bergman has developed an operator for this equation, wherein a flow can again be obtained for each analytic function. This operator requires knowledge of a certain function sequence which may be (and now is being) calculated once and for all. With this apparatus, all flow patterns may be obtained with comparatively little labor.

Hodograph methods for compressible flow. M. E. SHANKS, Purdue University.—Dr. Shanks discussed the types of hodographs obtainable from flow past an airfoil and pointed out problems unsolved even for incompressible flows. The case of supersonic flows and the method of characteristics was also discussed.

The achievement of large classes in mathematics. H. F. S. JONAH and M. W. KELLER, Purdue University.—The authors discussed the achievement of large classes in Mathematics in comparison with the achievement of small classes as measured by uniform objective tests. The classes compared were those in algebra and trigonometry.

Engineering applications of spherical trigonometry. P. M. PEPPER, Notre Dame University.—In this paper the author described some of the engineering applications of spherical trigonometry. Since its inception, spherical trigonometry has been applied principally to the sciences of astronomy, geodesy and navigation. It is little known that spherical trigonometry can be useful to the tool engineer, first, to derive the usual formulas for "compound angles" and, second, to solve atypical problems of this nature. Certain of the compound angle formulas are identified with Napier's Rules for right spherical triangles, whereas certain of the non-standard problems lead to the laws of oblique spherical triangles.

PHYSICS

Chairman: K. W. MEISSNER, Purdue University

Dr. B. A. Howlett, Rose Polytechnic Institute was elected chairman of the section for 1947.

ABSTRACTS

Interference spectroscopy. K. W. MEISSNER, Purdue University.—The application of interference phenomena in spectroscopy which was originated by Fizeau and further developed by Michelson, Perot, Fabry, and Buisson is of greatest importance for: (1) Absolute wave length measurements (Primary Standard), (2) Wave length measurements relative to the primary standard (Secondary Standards), (3) Study of intensity distribution in spectral lines, and (4) Special problems calling for such high resolving power which cannot be obtained with grating or prism spectroscopes.

The Interferometer of Perot and Fabry exhibits great advantages. It is simple in principle, not too expensive, and its resolving power can be adapted to the need of the special problems and can reach such an amount as never obtained with other spectroscopic instruments. Its application is more difficult than that of other spectroscopes but the evaluation of the interference patterns is rather simple. In combination with a prism or grating instrument it can be used for the study of spectra rich in lines.

If the eye piece of the spectroscope telescope is provided with an ocular micrometer the interferometric outfit is very useful for demonstration and instruction. Especially the determination of small wave length intervals is carried out very easily by measuring the diameters of a few consecutive circular interference patterns. Thus it is very useful for the qualitiative and quantitative study of Zeeman patterns in the student laboratory. By employing Helium, Neon, and Krypton Geisler tubes one has at his disposal many typical lines exhibiting normal and anomalous Zeeman splitting. A magnetic field of about 2000 Oersted is sufficient and it is easy to study the kind of light polarization obtained with the transversal and longitudinal effect.

Methods for naming new physical concepts. DUANE ROLLER, Wabash College.—The name for an important new quantity, device or process should be chosen with careful regard for nonambiguity, meaningfulness, internationality, simplicity and euphony. Examination of numerous existing terms in the light of these general requirements leads to a set of specific rules that make the choice of suitable new terms a comparatively simple matter. Possible sources from which to obtain new tech-

nical terms are: ordinary English, modern foreign languages, classical languages, coined words, the name(s) of the discoverer(s) of the concept. Often the most satisfactory procedure is to construct the new term from parts taken from classical Greek. Experience indicates that one should be indifferent to a question of terminology only if the concept involved is superficial or highly local in character; also, curiously, if it is not likely to have important applications in industry.

Experiments on contact rectification in germanium. S. BENZER, Purdue University.—The contact rectification between metals and germanium crystals is generally explained on the natural barrier layer theory in which the current in the forward direction is limited by the spreading resistance, while the current in the back direction is limited by a barrier layer due to the difference in work function between the metal and the semiconductor. If this theory applies, two pieces of the same germanium crystal when contacted with each other should show no rectification and the current-voltage characteristic should be linear and of resistance corresponding to the spreading resistance of the contact. However, if germanium alloys of the high black voltage type are contacted this way, the resultant resistance is much higher than is to be expected from spreading resistance alone. This indicates that these crystals have an artificial surface layer which has a large effect on the rectification observed with a metal cat-whisker.

Properties of P-type germanium rectifiers. RALPH BRAY and K. LARK-HOROVITZ, Purdue University.—The unit consisting of a pointed metal wire making contact with p-type (hole-conducting) germanium has rectifying, photovoltaic, photoconductive and thermal properties, which depend on the particular metal used, and the resistivity and surface treatment of the Ge crystal. Shining light in the immediate vicinity of the metal—Ge contact greatly increases the current in the high resistance direction (metal positive, Ge negative), but produced little change in the conducting direction. This effect may be so pronounced as to make it appear that the rectification is reversed. Heating the unit produces a similar effect, the higher the resistivity of the sample the lower the temperature at which the reversal takes place. Unlike the photo effect the thermal effect is quite insensitive to what metal is used. The photo effects are most sensitive to the frequencies in the infra red portion of the spectrum. The large increase in current produced by heat and light is probably due to the excitation of electrons from the full bank of the Ge semiconductor into the empty band. The energy necessary for such excitation ocrresponds to the frequency and temperature at which these effects occur. However, the great difference in magnitude between the effects in the low and high resistance directions can not be explained by the simple theory of a natural barrier between semiconductor and metal.

The shape of semiconductor resistivity curves. V. A. JOHNSON and K. LARK-HOROVITZ, Purdue University.—If resistivity as a function of temperature is measured for a group of semiconducting samples, the curves obtained differ in shape with the nature of the sample. As tem-

perature rises, the resistivity continually drops for one type of sample, for another type the resistivity rises to a maximum and then drops to a minimum, rises to a maximum, and then falls. This paper shows that the existence or non-existence of a maximum may be correlated with the Hall effect curve of the sample. It is shown that the position of the maximum, when it exists, may also be predicted from Hall effect data.

X-Ray investigations of germanium-tin alloys. L. DOWELL and K. LARK-HOROVITZ, Puprdue University.—Germanium alloys with small amounts of impurities do not show any differences in crystal structure as compared with pure germanium. However in samples to which 17% of tin had been added definite expansion of lattice has been found. Therefore, experiments were carried out in which starting with germanium tin alloy to which 17% tin had been added systematic dilutions with pure germanium were made. These experiments show that the lattice parameter as a function of concentration of tin changes linearly which would indicate that the tin is going into the germanium in a solid solution.

Decay of Phosphorescence in Sulfide Phosphors. HUBERT M. JAMES, Purdue University.—Many sulfides activated with impurity atoms emit phosphorescent light with intensity decreasing roughly inversely with t^2, t being the time elapsed since excitation. Certain of these phosphors, including ZnS activated by the addition of CuS, show a much more persistent phosphorescence with intensity inversely proportional to t over a large range of intensities. The inverse t^2 law of decay is understood on the assumption that the radiative process is the recombination of excited electrons with the vacancies available in the activating impurity atoms. The mechanism responsible for the inverse t law has not hitherto been understood. The slower decay of these crystals suggest that the excited electrons are trapped in the crystals, and thus prevented for some time from returning to the impurity atoms. It has been observed that large-grained ZnS gives an inverse t^2 decay, in contrast to the inverse t decay of the usual fine-grained material. This suggests that in the latter case the electrons are trapped on the extensive surfaces of the small crystals. The consequences of this assumption have been developed, and lead to a quantitative explanation of the decay of phosphorescence in Cu-activated ZnS, for times greater than 10^{-4} sec. after excitation has stopped. Deviation of observations from the theory for very small t appeared to be due to failure of the excited electrons to come into thermal equilibrium with the crystal in these very short times, whereas the theory assumes that such an equilibrium exists.

The 93 kev-γ-Line of UX_1. H. L. BRADT, Purdue University.—In the β-spectrum of UX_1 there occur L-, M-, and N-conversion lines of a 93 kev-γ-radiation. The fact that the wave-length as measured by Meitner is just the wave-length of the $K\alpha_2$ x-rays of the daughter product UX_2 suggested to Meitner that the observed β-lines are nothing but conversion lines of the UX_2-$K\alpha_2$ x-radiation. However, there seemed to be no acceptable reason for an excitation of this K-radiation. Our investigation of the β-spectrum and the γ-radiation of UX, using a magnetic spectrometer

and counters of calibrated efficiencies, leads to the result that the lines occurring in the β-spectrum are, with high probability, like the similar RdTh lines (Surugue and Tsien-SanTsiang), conversion lines of a nuclear γ-radiation. The L_1-conversion coefficient of this 93 kev-γ-radition has been determined from the intensity of the L_1-conversion line (0.05_1 electons/β-decay and the intensity of the unconverted γ-radiation (0.15 quanta/β-decay) as $N_e/N_q = 0.34$, in agreement with the theoretical value for quadrupole radiation, calculated by Fisk. The upper limit of the UX_1-β-spectrum has been determined as (0.205 ± 0.01) Mev. 80 percent of all β-transitions lead to UX_2 in its normal state, while 20 percent lead to the excited 0.093 Mev. level.

Measurements on microwave accelerator cavities. R. O. HAXBY, Purdue University.—The construction of a microwave linear accelerator for electrons has been started. An eighteen section accelerating tube has been constructed using loading every ½ wavelength. Measurements of other modes showed that the only interfering mode is one having seventeen half-waves in the eighteen sections. This mode, and other odd modes, may be removed by symmetrical feeding. Experiments have been performed on tube sections with varying loading, two tubes have been constructed for use in accelerating electrons with entering velocity less than c. Measurements are now in progress on one of these tubes to determine the proper geometry for coupling it to a magnetron.

Effects of a resonant load on the performance of a magnetron. F. F. RIEKE, Purdue University.—The effects of resonant loads on the performance of a magnetron are of current interest in connection with the proposed use of magnetrons as sources of high-frequency power for electron- and ion-accelerators. An essential feature of these accelerators is a high-Q resonant cavity in which intense electric fields are produced by excitation with power from a pulsed magnetron. The combination of magnetron, coupling element (a wave-guide) and the cavity may be considered as a system of circuits, which has several normal modes of oscillation. Only one of these modes has the configuration of electric fields which is effective for the functioning of the accelerator, so that some means must be found of insuring that this mode is excited consistently at each pulse. Experience with somewhat similar systems has shown that damping resistors inserted at appropriate points in the circuit are useful in suppressing undesirable modes of oscillation.

Diatomaceous earth as test object for electron microscope. H. J. YEARIAN, Purdue University.—Diatoms have long been used as a test object in light microscopy. They also prove useful with the electron microscope. A circular opening may be used to test for double images due to poor adjustment of the instrument. A regularly perforated plate photographed at different parts of the field aids in calculating the variation of radial and tangential magnification producing image distortion. The length of a row of perforations large enough to be identified in the light microscope may be measured and compared with that obtained from a series of photographs at the larger magnification of the electron in-

strument, to give a magnification calibration of the latter. Some of the finer details of the structure may also enable one to estimate the resolving power of the instrument. In the course of this work a number of examples have been found of a fine lacework across openings which are just resolvable in the light microscope. This structure usually consists of small circular openings symmetrically arranged about the center of the main opening.

The Helium Spectron in the Infrared. HELEN LOWENTHAL and K. W. MEISSNER, Purdue University.—The infrared spectra of normal and ionized Helium were investigated by the use of sensitized Eastman-Kodak photographic plates. Of special interest were the following results.

The Ortho-Helium line at 10 830A which is expected to be a close triplet appeared on the spectrograms taken with a 14 foot concave grating as a double line since the splitting of the triplet P level ($j = 1 \& 2$) could not be resolved. This unresolved strong component exhibited self reversal when the Geissler tube was used in "end on" position. This phenomenon is due to the metastability of the triplet S state involved. By making use of this absorption effect and by employing an interferometer definite resolution of the triplet structure was obtained. The previously unresolved components appeared now as definitely resolved absorption lines. The splitting of the P-levels was found to be: Triplet P (2,1) $= 0.078 \pm 0.002$ cm^{-1} and Triplet P (1,0) $= 0.994 \pm 0.002$ cm^{-1}. These values are in good agreement with those found by Meggers and Humphreys who measured the same line in emission.

The investigation of the ionized Helium by means of a hollow cathode light source was devoted to the study of the fundamental line of the Pickering series 10 123A the existence of which had previously been proved by Paschen and Ritschl. Although the line could be photographed with the grating and the wave length be measured (10 123.62 $\pm$ 0.02A) the study of the fine structure of this line was found to be impossible with the techniques available at the present.

PSYCHOLOGY

Chairman: C. C. Josey, Butler University

Dr. Alma Long, Purdue University, was elected chairman of the section for 1947.

ABSTRACTS

A further study of interpretations of human behavior given by adolescents. Alma Long, Purdue University.—*Hypothesis:* That clues to needs for education of youths may be derived from their interpretations of ordinarly life situations which involve emotional reaction between two or more persons. *Method:* The projective technique has been employed, in which illustrations of incidents common to modern family life were presented to children in grades seven to twelve of four representative schools in Indiana. Standardized tests procedure, timing and materials. Replies to three leading questions about what seemed to be taking place and what might be in the minds of the persons represented were requested. Supplementary data: Intelligence, Home quality, and Personality scores. *Findings:* Progress report of the analysis of 600 sets of responses: T-Scores derived from supplementary data serve to roughly classify individuals into the extreme and middle groups in relation to potential differences in personality traits and ability to interpret emotional aspects of human behavior. Within separate age and ability groups, outstanding achievement on the test focuses upon what seems to be indication of social or emotional maturity. Variations in response appear to be associated with the ability, experience and attitudes of the individual in patterns which are useful for individual guidance as well as for the furtherance of education toward improved human relationships.

Opinions of high school pupils concerning their course in psychology. T. L. Engle, Indiana University Extension Division.—Late in the spring of 1946 pupils taking courses in psychology in six Indiana high schools were asked to fill in a rating scale designed to measure their opinions concerning the value of various subject matter fields for meeting various educational objectives. A total of 276 pupils, 108 boys and 168 girls, filled in the rating scale. Mean scores for each subject matter field for each educational objective have been determined and the significance of differences in scores have been computed. It has been found that pupils believe psychology to be very valuable in meeting most of the objectives of secondary education but that it is especially valuable in meeting the objectives of training for worthy home membership and desirable personality. Pupils expressed the opinion that some subject matter fields other than psychology are of more value that psychology in meeting the citizenship and vocational objectives. Pupils favor the offering of more work in psychology at the high school level.

A Developmental Study of Feeblemindedness from Adolescence to Early Adulthood

Bernardine G. Schmidt, Indiana State Teachers College

The socio-psychological concepts of feeblemindedness have gripped man in varying emotions of disgust, revulsion, and sympathy since mediaeval times. In early days the dullard was considered to have been bewitched by devils, and in mistaken attempts to help him he was tortured and often killed, for only by such treatment could he be fully exhorted from his affliction. A later age considered its treatment more enlightened when it gave to the fool that place of questionable prestige accorded "the royal jester". In this latter capacity the dunce was sheltered from his more able fellows, and was provided with somewhat more than the essentials of food and clothing and dwelling.

Years of understanding and study have preceded the various roles which have been assigned to the feebleminded in society. Each has raised his status, and each in turn has been based upon a fuller interpretation of the place of the dullard in a world of competency.

Various types of governments accord differing responsibilities to individuals and groups within their structure; and, conversely, varying governments accord differing status to such individuals and groups. A democracy relies for its success on the participation of each of its members to his greatest capacity. Like the proverbial chain, the democratic social order is only as strong as its weakest link.

With this general principle of social philosophy as a guiding concept, attention was given to the role of the feebleminded in democratic living. Only to the degree that non-competents can become socially aware and vocationally adequate, can a society function which accords to the feebleminded as well as the gifted equal responsibility for the choice of leaders, the selection and enforcement of necessary law, and the intelligent co-operative action which is the true spirit of democracy.

In 1940, more than 98,000 children of school age were enrolled in special schools and classes for the mentally defective, and another 22,000 were in residential homes and institutions for the feebleminded, at a total cost of governmental funds—either State or Federal—in excess of 39 million dollars. The size of the problem is not small.

In an attempt to study some of the possibilities for good personal and social adjustment of children who were competently classified as feebleminded, a study was begun of 254 children, between the age of 12 and 14, all of whom were within an IQ range of 27 to 69, according to clinically administered individual intelligence tests; the mean IQ of the group was 51.7.

Before the referral to the special centers, at least two, and as many as four, testings had been made, covering the age span from 5 years to

age at enrollment time. Careful analysis of results of each of these testings, indicated a condition of psychological feeblemindedness, a classification determined by test results, and corroborated by case history information of out-of-test behavior.

Three experimental centers were established in the public schools of Chicago, to provide special programs of instruction and therapy for these children. The centers were regular day schools, in operation five hours per day, five days a week, and ten months of the year. They were housed in regular elementary schools, where they occupied sections of the building, while the remainder was in use by the children in regular classes in kindergarten and the first eight grades.

An analysis was made of the physical health, mental abilities and academic achievement of these children; their behavior patterns; and their family, educational and community backgrounds. Their predicated needs were found to be: (1) improvement in all school subjects, and informational subject-matter areas; (2) growth in emancipation and responsibility in personal behavior; (3) increased understanding of group relationships in the family, the school, and the community; (4) increased competency in the skills of social interaction; and (5) ability to use direct-response mechanisms in resolving conflict situations in the adjustment process. Their important psycho-biological needs were: (1) economic security; (2) social recognition; (3) belongingness, or acceptance by the group, and (4) a feeling of personal worth as a contributing member of a social group.

With this study of basic needs as a foundation, an educational program was planned to meet individual and group needs, and which was directed toward these goals: (1) development of desirable personal behavior; (2) improvement in the fundamental academic skills; (3) development of the manipulative arts; (4) improvement of work and study habits; (5) learning of occupational and related vocational information; and (6) pre-employment experience. Extensive visual and audial aids were used, with emphasis on pupil participation. The development of self-confidence through service to others was the key-note of method.

The experimental instructional program lasted for three years, after which the study was continued for an additional five years, in order to provide for an adequate evaluation of the post school careers of the children who had therein participated.

The evaluation procedure included clinical batteries of individual measures of intelligence, emotional stability, social maturity, and social adjustment, taken at entrance to the special center, and at every eighteen months thereafter, during the eight year period. One of the measures of the value of the program was the absolute individual change in intelligence and emotional maturity, as measured by changes in test results as well as in anecdotal records of the post-center activities of these boys and girls in voluntary advanced schooling, in vocational adjustment and efficiency, and in social adjustment in their families and communities. A second evaluative measure was obtained from a comparison of careers and test results of a selected group of pupils from the experimental centers with the case histories of a non-experimental group individually

paired on the basis of original IQ, amount of previous school experience, initial academic achievement, sex, and socio-economic background. Further comparative data were obtained from the study of seven pairs of identical twins included in the study, wherein one of each pair had been in the experimental program, while the other had been in regular classes, in the case of four pairs; or in non-experimental special rooms, in the case of three pairs.

At the close of the three year in-school period, the group showed an average gain of three years and eight months in composite academic achievement; the range in gain was from 2.6 to 4.7 years. The average gain in reading was 4.1 years, with a range in gain from 2.4 to 4.7 years.

The average rate of gain in composite achievement during the in-school period was 120, although the average IQ of the group (at entrance) was 51.7; the average achievement level at special center withdrawal was that of the second month of the fifth grade, although the average grade expectancy calculated for the group according to their mental age at the close of the in-school period (on the basis of original entrance IQ) was the third month of third grade. The achievement of the group as a whole exceeded their expectancy by almost two years.

In test intelligence, individual over-all change for the eight year period ranged from a drop of 4 IQ points to a gain of 71 points. The mean over-all change was 40.7 IQ points. Eighty and seven-tenths per cent of the group exceeded a gain of 30 IQ points; 59.3 per cent reached or exceeded a gain of 50 points. By the end of the study, 59.7 per cent of the total group were classifiable as low or high normals; only 7.2 per cent were still feebleminded.

On measures of emotional stability and maturity, 79 per cent were shown to have attained a level of personal and social adjustment equal to or better than the highest one-fifth of well adjusted adults. A correlation of $.923 \pm .029$ was found between test intelligence and change in emotional stability over the full eight years of the study.

By the end of the study, more than 27 per cent had completed a four year high school course, and over 5 per cent had continued post high school training. Eighty-three and four-tenths per cent were regularly employed, and of this group one-third were in skilled occupations, and another third were in clerical positions. An additional 5.1 per cent were in inspection positions, where precision of final products was their responsibility.

Their salaries ranged to $84 per week with a median salary for the total group of $32. Almost 84 per cent of the group were still employed at the close of the study. The mean duration for all jobs held in the five year post school period was 3.5 years.

At the close of the study 83.4 per cent were regularly employed, 5.4 per cent were in military service (including two WAC's); 3.5 per cent were girls who had married and gave their full time to homemaking; 3.1 per cent were temporarily idle; and 2.4 per cent were in full-time school attendance. Two had died during the course of the study.

Fifteen of the girls and three of the boys were married by the end of the study. There were no records of personal maladjustment or economic

dependency within these units, as evidenced by the lack of contacts of these families with social agencies. Eleven families had children, ranging in ages from four months to four years. Although no study was made of these nineteen children, medical and clinical records available indicated apparent physical and mental normalcy. There was only one intermarriage within the study.

In the control group little change was found in any of the areas of behavior invesigated, although IQ change ranged from a gain of four points to a loss of 22 points. The mean IQ change for the control group was a drop of 3.6 points.

While human behavior involves so great a multiplicity of variables, unknowable and immeasurable, that casual relationships are difficult to establish, the data have shown the children in this study to have reached a degree of personal and social adjustment, and a level of mental, academic, and vocational competency equivalent to that of the average normal adult of years comparable to their age at the close of the investigation, despite the fact that originally these children had been classified as feebleminded.

ZOOLOGY

Chairman: HOWARD H. VOGEL, JR., Wabash College

Dr. A. E. Reynolds, DePauw University was elected chairman of the section for 1947.

ABSTRACTS

Studies of the behavior of birds and mammals. HOWARD H. VOGEL, JR., Wabash College.—This paper and the accompanying motion pictures illustrated some of the research work carried out during the summer of 1946 at the Hamilton Station of the Roscoe B. Jackson Memorial Laboratories at Bar Harbor, Maine, where the author was a summer investigator. Dr. Calvin Hall of the Department of Psychology of Western Reserve University did some experimental work on the differences in audiogenic seizures in inbred strains of mice. Motion pictures were taken of the fatal seizures usually seen when mice of the dba strain were exposed to the steady ringing of a telephone bell for a two minute period. Motion pictures show some of the large observation fields in which different varieties of dogs were kept for studies of normal behavior in the field. Experiments were carried out among eleven Springer spaniels to test for the social organization among these dogs. The results of these experiments show that the springer spaniels are not highly imitative. In addition to behavior studies in the field, physiological studies were carried on in the laboratory on the same dogs. Motion pictures showed some of the apparatus used by Dr. John Fuller, physiologist from the University of Maine, in charge of this work. Motion pictures of several birds of Mount Desert Island, Maine, illustrate differences in behavior in the following avian species: Loons (with young); young Hermit thrushes; Spotted sandpipers; immature Leach's Petrels; and the American Egret. The record of the egret was the first from Mount Desert Island, Maine.

The use of minor postglacial drainage connections by fishes in Indiana. SHELBY D. GERKING, Indiana University.—A detailed study of the distribution of the fishes of Indiana indicates that fishes used minor postglacial connections between the Great Lakes and Mississippi drainages in their northward migration as well as the major connections, i.e. the Chicago outlet and the Maumee river. The distribution of the ironcolor shiner, *Notropis chalybeus*, distinctly shows that connections between the Kankakee-Iroquois drainage and the Tippecanoe river and also between the Kankakee and St. Joseph rivers were used as the minnow invaded Indiana. There is also evidence that the ecological habitat of the ironcolor shiner was present in northwestern Indiana in early post-

glacial times. Distributional patterns of the western banded killifish, *Fundulus diaphanus menona*, the western lake chubsucker, *Erimyzon succetta kennerlii*, the spottail shiner, *Notropis hudsonius*, and the blackchin shiner, *Notropis heterodon* also imply use of the minor connections between the Great Lakes and Mississippi drainages. Many other fishes are so widespread in the state that their migratory routes are obscure, and it is assumed that these species used all, or at least most, of the available pathways.

The life cycle of *Samia cecropia*. JOHN W. BAECHLE, St. Joseph's College.—This paper consisted of a detailed description of the life cycle of *Samia cecropia* illustrated with 65 black and white slides and 12 Kodachrome slides. The kodachromes were copies of 12x16" hand colored enlargements of the outstanding phases of the life cycle. Photographs and slides were made by the author in connection with his raising and observing *Semia cecropia* over a period of three years.

The relation of survival time of the respiratory centers in the isolated mouse head to age. RICHARD K. THOMS and WILLIAM A. HIESTAND, Purdue University.—The isolated mouse head, cut off from the body at a level posterior to the posterior margin of the forelegs, shows a period of gasping until the respiratory mechanism fails. Gasping continues in the isolated head of one day old mice for over 25 minutes, the period growing less as age progresses until it reaches a final duration of only about 16 seconds in mice of 20 days of age. From 20 days on the period remains remarkably constant. The young mouse until it reaches about 19 to 20 days of age shows two periods of gasping, an initial period of gasping lasting anywhere from 10 to 32 seconds followed by a long period of slow gasps progressively growing shorter until it disappears completely. A similar condition has been reported for the white rat. It is believed that the energy for the initial series of gasps is aerobic while that for the second series is anaerobic.

The effect of posterior lobe principles and certain amines on the melonaphores of Anolis Carolinensis. WILLIAM B. HOPP and WILLIAM A. HIESTAND, Purdue University.—In an investigation of various sympathomimetic substances on melanophore responses in Anolis, certain amines were found to have a "sympathomimetic" effect, others had none. Among other substances, pituitary extracts were tried. Isolated extracts of posterior pituitary as well as whole pituitary cause expansion of melanophores. Using commercial isolated posterior lobe principles, it was found that the pressor ("pitressin") but not the oxytocic ("pitocin") principle caused melanophore expansion. The effect of pitressin is not destroyed by prolonged autoclaving. No other substances used produced expansion of the melanophores; all others caused melanophore contraction or were inactive. Substances showing sympathomimetic effect similar to epinephrine were neosynephrine, nethamine, and privine. Aminoheptanes and aminohexanes tried were without effect. Ergotoxine does not reverse the effect of pitressin as it does with adrenaline, which latter fact was previously reported. To determine if tissue extracts in

general might have the same effect as pituitary gland extracts, aqueous extract of dried liver was also tried and found to be without effect on the melanophores. In all trials (totaling 44) each substance was injected hypodermically in the subscapular region of the live animal.

The Effect of Quinacrine Hydrochloride on Cecal Coccidiosis of Chickens

J. W. Bamberger and W. E. Martin, DePauw University

Coccidia of fowls were seen at various times during the later half of the nineteenth century. However, it was not until the works of Tyzzer, Theiler, Jones, and Johnson, published between 1923 and 1932, that a clear distinction was made between the species involved; that the life cycles were traced, and that the pathology was described.

Of the six commonly recognized species of coccidia infecting chickens, (namely, *Eimeria tenella*, *E. mitis*, *E. acervulina*, *E. maxima*, *E. necatrix*, and *E. praecox*,) *E. tenella* is undoubtedly the most highly pathogenic. Its life cycle and host-parasite relationships are essentially the same as those of the other five species. The life cycle, according to Becker (1934), is as follows: *Eimeria tenella* is an intracellular sporozoan parasite of the cecum of the chicken. The bird is infected by ingesting sporulated oocysts which excyst as a result of the action of pancreatic and duodenal enzymes upon them. The liberated sporozoites migrate into the cecum where they invade the epithelial cells of the mucosa. The sporozoites, now called schizonts, undergo nuclear and cytoplasmic division to give rise to the first generation merozoites. The mature merozoites break out of the epithelial cells and invade nearby epithelium. The infected epithelial cells become considerably enlarged and migrate to a sub-epithelial position where they serve as host to second generation merozoites. When the second generation merozoites are fully developed, they erupt from the epithelial cells. Extensive hemorrhage and mucosal sloughing occurring at about this time liberate the merozoites from their sub-epithelial position. The merozoites again penetrate epithelial cells wherever they may persist and become the precursors of gametocytes. The epithelium invaded by these second generation merozoites is not stimulated to growth nor does it develop the wandering properties of cells infected by first generation merozoites. Whether or not this process of asexual reproduction may continue indefinitely, or is limited, is a point which has not been positively settled. However, the consensus of opinion is that the infection is a self limiting one. After these two schizogonies, the parasites enlarge and assume the morphological characteristics of either macrogametocytes or microgametocytes which subsequently become macrogametes or microgametes. The mature gametes are squeezed out of the epithelial cell and fertilization, which has never been observed, probably ensues. The fertilized oocysts are voided by the bird and final development, the formation of the sporocysts and sporozoites, takes place in the soil.

In general, the species of *Eimeria* infecting chickens show a marked host specificity. All of these species induce immunity reactions. The

immunity to a single species is effective only against that species, for cross-immunity reactions do not occur.

Following the ingestion of sporulated oocysts, there is a seven day prepatent period at the end of which time oocysts may be demonstrated in the droppings. However, birds receiving lethal infestions may not live through the prepatent period but show symptoms of severe hemorrhage on the fourth or fifth day, the infection causing death on the fifth, sixth, or seventh day.

Methods of treatment involve the use of drugs; i. e., arsenicals, sulfa derivatives, sulphur, mercurials, and others; and modifications of diet. These remedies leave much to be desired. Some are highly toxic, resulting in retarded development of the host. Some have only prophylactic value, since they are not effective after symptoms appear. Prognosis in coccidial infections in chickens is not good.

The fact that quinacrine hydrochloride or "atebrine" has been shown to be very effective against malarial protozoa; the coccidium, *Isospora hominis*, Railliet and Lucet, 1901, parasitic in man; and, according to Brumpt (1942), treatment of coccidial infections of rabbits, led us to believe that it might be effective in cecal coccidiosis in chickens.

Dr. C. A. Herrick of Wisconsin University graciously supplied us with a culture of oocysts of *Eimeria tenella*, Railliet and Lucet, 1891. In order to build up the culture, sub-lethal doses of these were given to a group of birds. The resulting oocysts were sporulated in aerated, five percent aqueous potassium dichromate. Sporulated oocysts in normal saline stored in the refrigerator survived better than non-sporulated oocysts. The crystalline quinacrine hydrochloride used in the experiments was generously given by the Department of Medical Research, the Winthrop Laboratories, New York. Only freshly made solutions of quinacrine were given to the chickens as solutions of the drug tend to become toxic upon standing.

Fifty-six of the ninety chickens used in our experiments were of the Brown Leghorn variety and were hatched in the laboratory. Thirty-four White Rocks were obtained from the Farm Bureau hatchery as one-day-old chicks. Every precaution was taken to prevent accidental infection of the stock colony. The young chicks were kept in a heated, wire-floored brooder battery, and older birds were kept in wire-floored cages. The brooder and cages were cleaned daily. Chicks up to twelve weeks old were give a dry, milk-sugar starter diet, and older birds were fed a fifty-fifty mixture of chicken scratch and cracked corn. Food and water were kept in the brooder and cages at all times.

Three different parasite-drug combinations were used to test the effectiveness of the quinacrine. In the first experiment, fifteen, twelve-week-old Brown Leghorn chickens were banded and divided into three groups of five birds each. Each group was placed in a large wire-floored cage and the cages were widely separated. The birds in group one served as the drug control group, receiving quinacrine but no coccidia, and will hereafter be referred to as the quinacrine control group. Group two was the drug test group. The birds in this group were given both coccidia and quinacrine. Hereafter, the birds in this group will be re-

ferred to as the quinacrine test group. Group three functioned as the coccidium control group and received only parasites. The initial infections of the quinacrine test group and the coccidium control group were accomplished by giving the chickens, orally, by pipette, approximately 20,000 sporulated oocysts of *Eimeria tenella*, Railliet and Lucet, 1891. Twenty-four hours after this initial infection three birds were given a booster infection of 20,000 sporulated oocysts. Immediately following the administration of the second dosage of coccidia to the quinacrine test group and the coccidium control group, drug therapy was started on the birds in the quinacrine control and quinacrine test groups. The drug, dissolved in distilled water, was administered orally, by pipette, and each bird received ten milligrams of quinacrine per kilogram of body weight every four hours, five times a day, for seven days. Thus each bird received, in toto, 350 milligrams of drug per kilo. Droppings were checked daily for parasites. Seven days after the initial infection, a few oocysts were found in the feces of the chickens in the quinacrine test and the coccidium control groups. Concentrations of the droppings of the quinacrine control group failed to reveal any parasites. Drug therapy was suspended for twenty-four hours, and the birds in the quinacrine test and coccidium control groups were re-parasitized with approximately 300,000 sporulated oocysts of *E. tenella*, per bird, given in two 150,000 oocyst infections, twelve hours apart. Quinacrine therapy was resumed in the quinacrine control and quinacrine test groups, each bird receiving fifty milligrams per kilo of body weight every twenty-four hours for seven days. Seven days after reinfection the birds showed symptoms of coccidiosis and oocysts were present in the droppings. Concentrations of droppings from the quinacrine control group revealed no parasites. All droppings in the quinacrine test group and the coccidium control group, containing occysts, were carefully transferred to two five per cent solutions of potassium dichromate. After forty-eight hours in the dichromate solution all fertilized oocysts, comprising ninety-five per cent of the total number, were sporulated. In making the oocyst counts, the droppings were first washed with tap water to remove the larger food particles. After forty-eight hours the oocysts settled out completely and the excess fluid was drawn off. Both specimens were diluted to 500 cc. with normal saline. In making the counts, the specimens were agitated thoroughly to insure uniform distribution of the oocysts. A sample of the specimen was quickly pipetted off and placed in a haemacytometer chamber, and the number of oocysts in 0.9 cubic millimeters of sample was determined. At least five counts were averaged for each specimen.

In the second experiment, fourteen thirteen-week-old Brown Leghorn chickens were divided into two groups of five birds each, and one group containing four birds, as in the first experiment. The quinacrine test group and the coccidium control group received approximately 300,000 sporulated oocysts of *E. tenella* as a 150,000 oocyst initial infection and a 150,000 oocyst booster given six hours after the first infection. The purpose of this experiment was to determine the value of quinacrine as a therapeutic agent when administered after symptoms appear. Seven days after the initial infection, the birds in the quinacrine test group

and the coccidium control group showed symptoms of coccidiosis; that is, blood, mucus and occasional trophozoites in the droppings, leg weakness, and decreased food and water intake. At this time drug therapy was started on the birds in the quinacrine control group and in the quinacrine test group. These birds received orally, by pipette, fifty milligrams of quinacrine per kilo of body weight twice a day. The dosages were given twelve hours apart. Drug therapy was continued for two days so that each bird received 200 milligrams of quinacrine per kilo of body weight. Droppings, containing oocysts, from the quinacrine test group and the coccidium control group were kept separate and treated as in Experiment One. The quinacrine control group was negative for accidental infection.

In Experiment One, infected birds receiving no quinacrine had an average oocyst count of 34 per 0.9 cubic millimeter sample of droppings, while infected birds receiving quinacrine had an average oocyst count of 32 per 0.9 cubic millimeter. In Experiment Two, infected birds receiving no quinacrine had an average oocyst count of 232 per 0.9 cubic millimeter sample of droppings, and infected birds receiving quinacrine had an average oocyst count of seventy-seven per 0.9 cubic millimeter. Although the birds in Experiment One received somewhat heavier infections, their oocyst counts were considerably less than the counts in Experiment Two. This difference in oocyst count possibly can be attributed to the manner in which the birds were infected. The birds in Experiment One were given two infections of oocysts with sufficient time between them for the first to have been completed before the second infection was given. Hence, there is a possibility that a partial immunity was developed. The difference between the oocyst counts in Experiment Two apparently can be attributed to the action of the quinacrine in reducing the production of oocysts.

Experiment Three was designed to determine the therapeutic value of quinacrine in lethal coccidial infections. In this experiment, twenty three-week-old White Rock chicks were placed in individual wire-floored cages, and the cages were divided into four equal groups. One group of birds received neither coccidia nor quinacrine. The quinacrine control group was given only the drug. The quinacrine test group received both quinacrine and a lethal infection of coccidia, and the coccidium control group received only a lethal infection of oocysts. An initial infection of approximately 200,000 sporulated oocysts of *E. tenella* was given each chick in the quinacrine test group and in the coccidium control group. A booster dose of approximately 200,000 sporulated oocysts was given each bird forty-eight hours after the first infection. The quinacrine therapy, which was started twenty-four hours after the initial oocyst infection, was given orally, by pipette. Each bird in the quinacrine control group and the quinacrine test group received one fifty milligram dose of quinacrine per kilo of body weight every twenty-four hours. Therapy was given for five days; thus, each bird received a total of 250 milligrams of quinacrine per kilo of body weight. All infected birds showed symptoms of the disease five days after the initial infection, and all died on the sixth day. Controls were negative for infection. The conclusion drawn from

this experiment is that quinacrine hydrochloride in a dosage of fifty milligrams per kilo of body weight per day does not have therapeutic value in cecal coccidiosis in three-week-old chickens given lethal infections of *E. tenella.*

Dosages of quinacrine up to fifty milligrams per kilo of body weight per day, for a maximum of fifteen days, had no apparent injurious effect upon the chickens.

Measurements of oocyst size and pathological findings indicated that we were uing *E. tenella.*

Summary

1. Sublethal doses of *Eimeria tenella,* Railliet and Lucet, 1891, seem to produce prompt immunity.

2. Quinacrine hydrochloride may reduce the number of oocysts voided in the feces in sublethal infections of *E. tenella.*

3. Quinacrine hydrochloride in a dosage of fifty milligrams, per kilo of body weight, per day, does not have therapeutic value in cecal coccidiosis in three-week-old chickens given a lethal infection of *E. tenella.*

4. Dosages of quinacrine hydrochloride up to fifty milligrams per kilo of body weight per day, for a maximum of fifteen days, had no apparent injurious effect upon the chickens.

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Notes on the Ecology and Taxonomy of Certain Pupae of the Family Tenebrionidae (Coleoptera)

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The pupae of insects are not as well known as their larvae and imagoes. It is likely that a thorough study of the morphology of pupae would contribute much of value to taxonomy. At present it is not possible to give family characterizations of the pupae of even the larger and otherwise well-known families of Coleoptera. The following key and ecological notes are the result of the personal collections and observations of the writer over the past nine years. Unless otherwise stated, each species was taken in the northern tier of counties (Lake, Porter, Laporte, St. Joseph, Elkhart, Lagrange, Steuben), as well as from both Wayne and Rush Counties. The pupae in each case were named by rearing and determining their imagoes.

ECOLOGY

The Indiana species of the family Tenebrionidae may be placed, on the basis of larval and adult habits, in three groups: (1) grain inhabitants, (2) decaying-wood inhabitants, and (3) fungus inhabitants. The pupae of the first group occur in the open or beneath whatever cover may be at hand; those of the second group occur beneath bark or in burrows in the wood (often the burrows are enlarged to form special pupal cells); the pupae of the third group occur in burrows in the fungi.

Grain-Inhabiting Species

Tenebrio obscurus Fab. and *molitor* L. These species are common around stored grain and grain products. Prior to pupation the larvae tend to wander away from the feeding site and pupation usually occurs beneath loose cover, but if cover is lacking pupation occurs in fully exposed places. Under normal conditions pupation takes place in the spring, but under special laboratory control it may take place in any month. The life cycle has been extensively studied by many workers. Cotton and St. George (1929) summarize the published data on the pupae and give a good bibliography.

Tribolium confusum Jacq. Duv. This is another very common species and is found wherever grain products are carelessly stored. Pupation occurs in the open or beneath whatever cover is available. Under favorable conditions pupation occurs throughout the year. The pupa has been figured by numerous workers.

Alphitophagus bifasciatus (Say). This species was collected only in Rush County, though it probably is common throughout Indiana. It is most likely to inhabit molding grain and subsists largely on the fungus rather than the cereal. Pupation occurs in debris near the source of food. Schiödte (1879) figures and describes the pupa; Chittenden (1917) reports that the pupal stage lasts six days during hot summer weather.

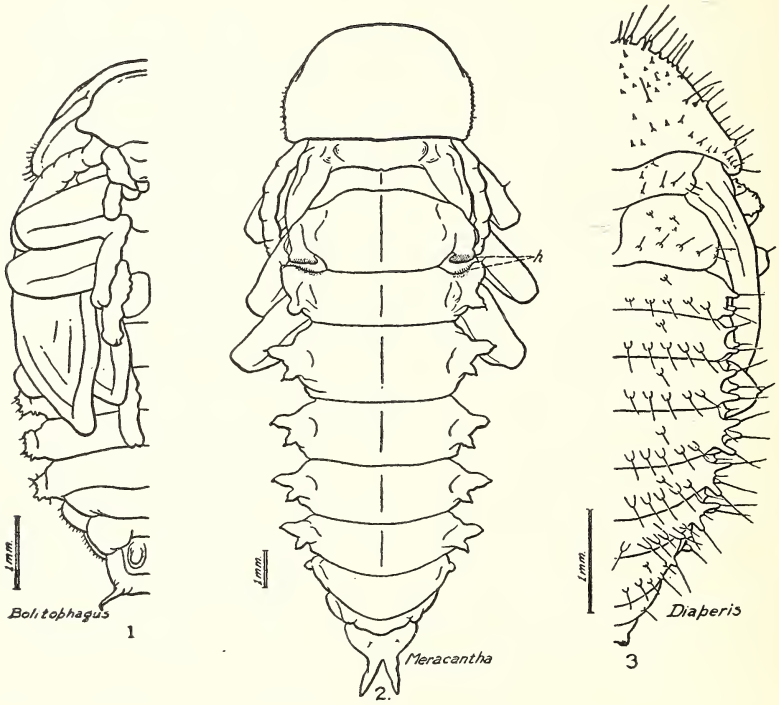

Plate I. Pupae of Tenebrionidae. Scales indicated.

1. *Bolitophagus corticola* Say. Ventral view, right half.
2. *Meracantha contracta* (Beauv.). Dorsal view; h, hinge-like structure.
3. *Diaperis maculata* Oliv. Dorsal view, right half.

Fungus-Inhabiting Species

Bolitotherus cornutus (Panz.). This is an extremely common species. All of its stages occur in woody fungi, in Indiana chiefly in *Fomes applanatus*. Pupation, which occurs from May through August, takes place in tunnels excavated in the fungus by the larva. The pupa was first described by Candèze (1861).

Bolitophagus corticola Say. This is a relatively rare species. The writer's only collection was from Richmond in September. All stages were found in a woody polyporous fungus growing at the base of a living

black locust tree. The pupae were present in the burrows made in the fungus by the larvae. The pupa of this species has never been described.

Diaperis maculata Oliv. This species is fairly common. It inhabits woody and semi-woody fungi but is rarely found in the hard, dry fungi occupied by *Bolitotherus*. Pupation, which occurs in late summer (July

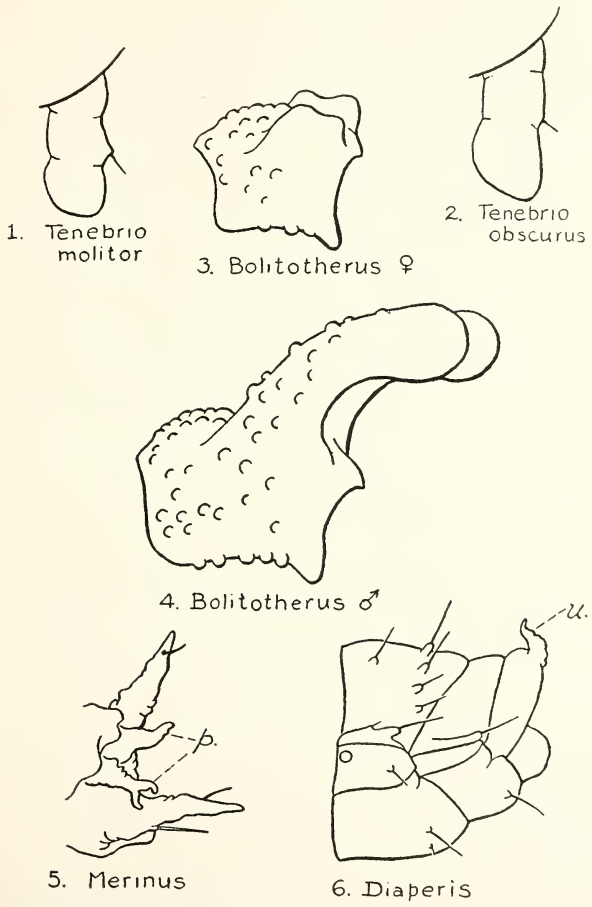

Plate II. Details of Pupae of Tenebrionidae. Not drawn to scale.

1. *Tenebrio molitor* L. Left maxillary palpus, ventral view.
2. *Tenebrio obscurus* Fab. Left maxillary palpus, ventral view.
3. *Bolitotherus cornutus* (Panz.). Pronotum, right view, female.
4. *Bolitotherus cornutus* (Panz.). Pronotum, right view, male.
5. *Merinus laevis* (Oliv.). Ninth segment of abdomen, dorsal view; p, fleshy projections. Drawn from distorted exuviae.
6. *Diaperis maculata* Oliv. Seventh, eighth, ninth, and tenth abdominal segments, right view; u, urogomphus.

through September), takes place in special oval cells with walls made by cementing particles together. Figures of a larva and a pupa prepared by C. V. Riley and published by LeBaron (1874) were erroneously labeled *Diaperis maculata*. Blatchley (1910) in his *Beetles of Indiana* copied the figure of the incorrectly named larva. No authentic account of the pupa has been published.

Wood-Inhabiting Species

Strongylium sp. The immature stages of this genus are represented by a single collection from Richmond. The larvae were found in burrows in the dead, moist branches of living willow trees; a single larva subsequently transformed. Pupation took place in the laboratory on May 25 in an enlarged cell in the wood occupied by the larva. The pupa transformed to the imago after nine days. The pupae of the North American species of this genus have not been mentioned in the literature.

Tenebrio picipes Hbst. This species is most commonly associated with dead wood, though it is also found in a variety of other habitats. St. George (1924) records the larvae in a nest of *Bombus* and on strawberries. Although *T. picipes* is not associated with grain, its cosmopolitan distribution, varying habits, and relation to the mealworms suggest that it might infest grain on occasions. Pupation occurs during July and August beneath the bark of logs or beneath pieces of wood within oval cells formed in the surrounding detritus by movements of the prepupa and pupa. The pupal stage lasts nine days. No accounts of the pupa of *T. picipes* have been published.

Scotobates calcaratus (Fab.) This is a common inhabitant of decaying logs. Pupation was not observed in the field so the natural time and place of pupation are unknown. In the laboratory the larvae pupated during May and June. The pupal stage, in one instance, existed eleven days. Beutenmüller (1891) briefly mentioned the biology of the pupa of *S. calcaratus*.

Merinus laevis (Oliv.). This is a moderately common species, found much more abundantly in the larval than in the adult stage. Pupation occurs in cells in the detritus beneath the bark of logs and takes place in June and July. St. George (1924) gives a detailed description of the pupa of *M. laevis*.

Alobates pennsylvanica (DeG.). The adults of this species are much more abundant than those of *Merinus laevis*. The larva prepares an elongated pupal cell, usually about an inch deep in the wood. Pupation occurs from June through August and the pupal stage lasts eleven to twelve days. The pupae of *Alobates* have not been recorded in the literature.

Xylopinus saperdioides (Oliv.). In Indiana this species is common in both the larval and the adult stages. Pupation takes place in May and June in a cell in the detritus beneath the bark of logs. There are no published accounts of the pupa of *X. saperdioides*.

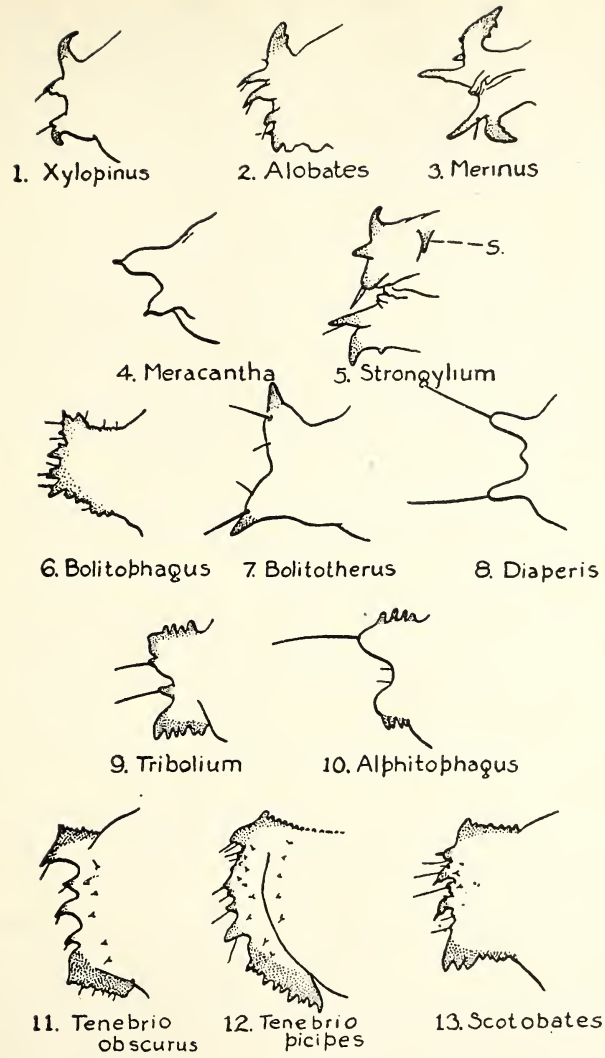

Plate III. Lateral abdominal plates of Pupae of Tenebrionidae; dorsal view of left plate of third abdominal segment, unless otherwise stated. Not drawn to scale. Stippling indicates sclerotization.

1. *Xylopinus saperdioides* (Oliv.). Fourth abdominal segment.
2. *Alobates pennsylvanica* (DeG.).
3. *Merinus laevis* (Oliv.). Fourth abdominal segment. Drawn from distorted exuviae.
4. *Meracantha contracta* (Beauv.).
5. *Strongylium* sp. Ventral view of right plate; s, spine ventral to plate. Drawn from distorted exuviae.
6. *Bolitophagus corticola* Say
7. *Bolitotherus cornutus* (Panz.)
8. *Diaperis maculata* (Oliv.)
9. *Tribolium confusum* Jacq. Duv.
10. *Alphitophagus bifasciatus* (Say)
11. *Tenebrio obscurus* Fab.
12. *Tenebrio picipes* Hbst.
13. *Scotobates calcaratus* (Fab.)

Meracantha contracta (Beauv.). This species is less restricted to decaying timber than the other pupae in this group. Larvae occur beneath bark, chunks, or other cover, as well as in decaying logs; they are capable of making burrows in solid wood. Pupation occurs in April or May beneath the bark of logs or beneath pieces of wood. The pupal stage lasts for about nine days. Hyslop (1915) gives an adequate description of the pupa and discusses its ecology.

TAXONOMY

The following key to the tenebrionid pupae here considered is, so far as possible, based on characters that can be discerned on the pupal exuviae as well as the whole pupa. Obviously, since only a small proportion of the Indiana species of the family are considered, the key is limited in application. It will serve, however, for the majority of specimens collected in wood, since it includes all the more common ones.

KEY TO SOME OF THE PUPAE OF THE FAMILY TENEBRIONIDAE IN INDIANA

a. Second and third thoracic segments together shorter than first abdominal segment; legs and antennae very long; maxillary palpus strongly dilated; first and second abdominal segments with well sclerotized hinge-like structures; lateral plates simple, bifid (plate I, fig. 2; plate III, fig. 4) ..... *Meracantha contracta* (Beauv.)

aa. Characters partly or entirely different

b. Ninth abdominal segment broadly truncate, bearing urogomphi separated at their bases by approximately their length; legs short and stout; elytra reaching to or nearly to claws of metathoracic legs.

c. Prothorax with pair of tubercles, relatively short in females, very long in males; lateral plates bifid (plate II, fig. 3,4; plate III, fig. 7) ..... *Bolitotherus cornutus* (Panz.)

cc. Prothorax without tubercles; lateral plates with several teeth (plate I, fig. 1; plate III, fig. 6) ..... *Bolitophagus corticola* Say

bb. Ninth segment not broadly truncate, urogomphi narrowly separated at their bases.

c. Lateral plates bearing pair of finger-shaped tubercles unsclerotized at their tips; setae long, when borne on tubercles always at the distal end of tubercles

d. Oval in shape; abdominal terga with rows of fleshy setae-bearing tubercles; lateral plates with tubercles about equal and each bearing seta; urogomphi directed dorsad (pl. I, fig. 3; pl. II, fig. 6; pl. III, fig. 8) ..... *Diaperis maculata* Oliv.

dd. More slender and parallel; terga without special armature; lateral plates with posterior tubercle smaller and lacking seta; cranial and caudal margins of plates armed with minute sclerotized teeth; urogomphi directed caudad (pl. III, fig. 10) ..... *Alphitophagus bifasciatus* (Say)

cc. Lateral plates bearing various spine-like processes, always more or less sclerotized at their tips; setae often inconspicuous, usually but not always borne proximad to tips of spines

d. Elytra covering most of metathoracic femora, reaching nearly to ends of metathoracic tarsi; setae moderate, inserted at tips of tubercles and spines; lateral plates with sclerotized and serrated anterior and posterior margins and 2 or 3 short lateral tubercles (pl. III, fig. 9) ..... *Tribolium confusum* Jacq. Duv.

dd. Elytra smaller, leaving much of metathoracic femora exposed and reaching to less than half length of metathoracic tarsi; setae not inserted at tips of spines or tubercles; lateral plates variable

e. With strongly developed spines on abdominal segments ventral to lateral plates; lateral plates with 4 or 5 spines and without cranial and caudal sclerotized margins; body very slender (pl. III, fig. 5) ..... *Strongylium* sp.

ee. Without such strongly developed spines ventral to lateral plates; lateral plates variable; body stouter

f. Lateral plates with cranial and caudal margins sclerotized and serrate

g. Surface nearly glabrous, with only a few, more or less definitely placed setae

h. Caudal sclerotized margin of lateral plates not notably oblique

i. Last article of maxillary palpus dilated (pl. II, fig. 2; pl. III, fig. 11) ..... *Tenebrio obscurus* Fab.

ii. Last aricle of maxillary palpus nearly cylindrical (pl. II, fig. 1) ..... *Tenebrio molitor* L.

hh. Caudal sclerotized margin of lateral plate oblique, its outer angle nearly obsolete, its inner angle prolonged and acute (pl. III, fig. 12) ..... *Tenebrio picipes* Hbst.

gg. Surface evenly and densely covered by short, slender setae (pl. III, fig. 13) ..... *Scotobates calcaratus* (Fab.)

ff. Lateral plates without sclerotized cranial and caudal margins, but with dagger-like spine at cranio-lateral angle

g. Tergum of ninth segment with pair of fleshy projections terminating in single or forked apices (pl. II, fig. 5; pl. III, fig. 3) ..... *Merinus laevis* (Oliv.)

gg. Tergum of ninth segment without special armature

h. Lateral plates with 2 or 3 conspicuous spines between cranial dagger-shaped spine and caudal spine (pl. III, fig. 2) ..... *Alobates pennsylvanica* (DeG.)

hh. Lateral spines of lateral plates smaller and less conspicuous (pl. III, fig. 1) ..... *Xylopinus saperdioides* (Oliv.)

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